Popular Astronomy.

Vol. XXVII, No. 10 DECEMBER, 1919. Whole No. 270.

THE 100-INCH HOOKER TELESCOPE OF THE MOUNT WILSON OBSERVATORY.

GEORGE E. HALE, Director.

After a series of tests extending over several months, the 100-inch telescope of the Mount Wilson Observatory has been found to be a complete success. The construction of this instrument, begun several years ago, was necessarily an experiment, as it was by no means certain, after the optical and mechanical difficulties had been overcome, whether the atmosphere would be sufficiently tranquil to permit clearly defined images of celestial objects to be obtained with so large an aperture. Mount Wilson, situated in the favorable climate of Southern California, where the best of results have been secured with telescopes up to 60 inches aperture, is a site as promising as any that could be found. But as observations with smaller instruments are insufficient to settle the question, the actual performance of the telescope could not be predicted with certainty.

The tests, which permit the performance of the new instrument to be directly compared with that of the neighboring 60-inch telescope, show that the full gain in light-gathering power, to be expected from the increased aperture, has actually been attained. The 100-inch telescope thus collects nearly three times as much light as the 60-inch telescope, and concentrates it in images so sharp that the gain in brightness is fully utilized. This means that the atmosphereic conditions on Mount Wilson have proved to be good enough to meet the very severe demand.

The sharpness of astronomical photographs obtained with the 100-inch telescope may be judged from some large pictures of the moon, which bring out very small details. These were taken with the combination of mirrors that give the telescope an equivalent focal length of 134 feet. Photographs of small nebulae taken at this focus also show details of structure of great interest.

It will naturally be the policy of the Observatory to apply the 100-inch telescope chiefly to the study of faint and difficult objects beyond the reach of our smaller instruments. Hitherto most of the observations have been made with the aid of spectrographs attached at the 134 foot focus. The great light-gathering power permits the spectra of extremely faint stars to be photographed with moderate exposures. In this way the motions of faint stars in the heart of globular clusters and in the star-clouds of the Milky Way can be measured. By applying Adams' spectroscopic method of measuring the distances of stars, it will also be possible to distinguish between stars that are faint because they are small or feebly luminous and those that are actually bright but are rendered faint by their great distance.

A few results already obtained through the study of faint stars with the 100-inch telescope may be of interest. For the first time, except in the case of new or temporary stars, the unknown gas nebulium, the most conspicuous of the elements constituting the irregular cloud-like nebulae, has been found to be present in the atmosphere of a star (R Aquarii). This star is a faint reddish object, which varies greatly in brightness in a period of about a year.

A faint variable star in the constellation Taurus, associated with one of the few nebulae known to vary in brightness, has been found to have an extensive atmosphere in which brilliantly luminous clouds of calcium vapor are conspicuous. Another peculiarity of this star is its extremely high temperature when near its maximum brightness.

The faint companions of close double stars, when studied spectroscopically with the new telescope, have already yielded interesting results. Such systems are of great interest in the study of stellar evolution, but the fainter members, especially when very close to their bright companions, have previously been beyond the reach of our spectroscopes.

These examples will suffice to illustrate the present work of the 100-inch Hooker telescope, named for the late John D. Hooker of Los Angeles, donor of its optical parts. Several new classes of observations will soon be made with the aid of special appliances now nearing completion.

THE REFORM OF THE JULIAN CALENDAR.

ROSCOE LAMONT.

The average length of the Julian year is 365¼ days, which is about 11¼ minutes greater than the tropical year. Since there are 1440 minutes in a day, the number of years that must elapse before the excess amounts to one day will be found by dividing 1440 by 11¼, which gives 128. Therefore at the end of 128 years the time of the equinox would be one day earlier in the calendar. When the Julian calendar was established in the year 45 B. C. the equinox occurred about March 24, and in 325 A. D. it came about March 21. At this rate, in a little over 10,000 years the equinox would fall on the first of January, and in 22,000 years the fourth of July would come at the time of the winter solstice. This would not do at all, and in order to prevent any such occurrence the calendar was reformed again.

But the idea of the reformers was to restore the equinox to March 21, the day on which they supposed it came in the year 325, when a Council of the Church was held at Nicaea, in Asia Minor, which made a decision as to the time of celebrating Easter. One sect of the Christians, following the Jewish practice, observed the fourteenth day of the moon, on whatever day of the week it came, which fell on or next followed the date of the equinox; but the greater number condemned this practice, wishing to have nothing in common with the Jews, who boasted that without instruction from them the Christians wouldn't know when to celebrate Easter. When the Nicene Council was held the Romans placed the date of the equinox at March 18, and the Alexandrians at March 21, but modern astronomers who have written on this subject say that the equinox in the year 325 came on March 20. The Alexandrian determination appears to have been accepted, and the rule laid down that Easter was to be celebrated on the first Sunday after the fourteenth day of the moon which falls on or next after March 21, the date of the equinox, the computation to be made by the Church of Alexandria, the most skilled in the science of astronomy, and the Church of Rome to make it known. The Romans, however, continued to make their own computation, for Hefele, in his History of the Church Councils, says that in the very next year, 326, the Romans celebrated Easter on a different day from the Alexandrians, and that the same thing happened in the years 330, 333, 340, 341 and 343. But though councils might by decree fix the equinox at March 21, it none the less continued to come one day earlier in the month every 128 years, falling on March

11 in 1582 when the reform of the calendar was carried into effect, and to restore the date to March 21 the omission of ten days, or, better, the dropping of ten monthly dates, was necessary.

The question of the reform of the calendar had been discussed for more than three hundred years before it was carried out, and for a much longer time it had been known that the Julian year exceeded the tropical and that, therefore, the date of the equinox was retrograding. In a work by Boni de Luca, written in the year 1254, quoted by Duhem in his System of the World, is the following:

"It is known that when Christ was born the winter solstice fell on the day of the birth of the Lord, and then the days began to increase, and the summer solstice fell almost on the day of the nativity of Saint John the Baptist, the eighth day before the calends of July, when the days began to decrease. Therefore John says of Christ: It is necessary that he increase and that I decrease. But now the solstices and equinoxes have retrograded ten days, and that has happened on account of the error of our calendar, since the solar year is not completed in 365 days and 6 hours, but it lacks eight moments which are the fifth part of one hour. Thus in five years we are in error one hour, and in one hundred twenty years we are in error one day, and unless the error is corrected the festivals of spring will be found in the summer."

In the thirteenth century Roger Bacon, in a work transmitted to Pope Clement IV, proposed the reform of the calendar, saying:

"Julius Caesar, learned in astronomy, regulated the calendar as well as it was possible in his time, but he did not determine the true length of the year, which he placed at 365¼ days, which quarter of a day he combined every four years and in bissextile years computed one day more than in common years. It is found, however, by astronomical methods that the length of the solar year is not so great by almost the 130th part of one day, and, therefore, in 130 years one superfluous day is counted, which, if taken away, would free the calendar from this error."

Dealing with the subject again in another part of his work, he finds the error of the Julian year to amount to one day in 125 years, and he explains in the following way how this was determined:

"For Ptolemy, in the one hundred fortieth year from the Incarnation, found the vernal equinox to be on the eleventh of the calends of April (March 22), and the winter solstice on the eleventh of the calends of January (Decembr 22), as appears from the Almagest. But from this place in the calendar to the ides (13th) of December where the solstice now is there are nine days. Since the determination of Ptolemy 1127 years have elapsed, the present year being 1267, and 1127 divided by 9 gives 125 and 2 over. Therefore the date of the solstice and equinox recedes one day in 125 years."

In the histories of the calendar reform by Ferrari, Hagen and Kaltenbrunner, the names of more than twenty writers are mentioned who suggested methods of correction, and the question was considered by most of the Church councils that were held in the fifteenth and sixteenth centuries.

The French Cardinal Pierre d'Ailly, reformer and astrologer, who predicted in the year 1414 that in 1789 there would be great alterations and remarkable changes, especially in laws and religion, if the world

was then in existence, in writing on what needed reform did not overlook the calendar.* Cardinal d'Ailly's work was presented to the Council of Constance in 1417. He considered the error of the Julian year to equal one day in 134 years, and he therefore proposed to omit one day after every such period, but if the 134th year was not a leap year, then the year nearest the 134th which would ordinarily be reckoned as a leap year was to consist of 365 days, and he said that in gratitude for this correction that year would deserve to be called the year of jubilee. He did not advocate the omission of any days to restore the equinox to its place in the time of Julius Caesar or when the Nicene Council was held. To drop one day whenever the small excess of the calendar over the tropical year has accumulated to one day (in 128 years) would be the most accurate method of correction, although the omission of intercalations in centurial years, according to the plan adopted, is simpler and more convenient.

The most famous astronomer of his time was Johann Müller of Königsberg, commonly known as Regiomontanus from his birthplace. In 1474 he published his Calendarium giving the time of the occurrence of solar and lunar eclipses for many years in advance, with diagrams showing their magnitude. In Thacher's Life of Columbus there is a photograph of a page of this calendar, and it was by means of the work of the Königsberg astronomer that Columbus on his fourth voyage, when stranded on the Island of Jamaica, was able to predict the lunar eclipse of February 29, 1504, when he told the Indians that because of their refusal to supply him with provisions God would punish them, and show his anger by giving the moon a bloody hue that very night, a drawing of this particular eclipse being one of those reproduced by Thacher. Pope Sixtus IV resolved to make his Pontificate illustrious by reforming the calendar, and having created Regiomontanus Bishop of Ratisbonne, invited him to Rome in 1475 to engage in the work. Regiomontanus, however, died the next year in Rome at the age of forty, some authorities say of the plague and others that he was poisoned, and, Dreyer says, "the chance was thus lost of getting the proposed reform accomplished while the whole of Christendom still acknowledged the supremacy of the Pope."

In Marzi's work, "The Question of the Reform of the Calendar in the Fifth Lateran Council", published in Florence in 1896, a full account is given of the efforts made at that time to bring about the re-

*The Cardinal made another pretty good hit, writing in 1418: "From the astronomical conjectures set forth it is not possible to conclude anything with certainty, but yet from these and other considerations above mentioned, it may be inferred as probable that in a century from the present year there will be violent contentions about laws and sects, and especially about the law and Church of Christ." An astrologer might consider this as foretelling, after a look at the stars, the Protestant Reformation which began in 1517. As an astrological prophet the Frenchman was in a class by himself, although if the number of times he missed were counted his average would probably be low.

form. This council met in Rome in 1512, and Paul of Middelburg, a city in Holland, was the prime mover in the matter of correcting the calendar. Letters were sent to the various rulers of Europe asking for advice and assistance. Pope Leo Tenth wrote to Henry the Eighth, King of England (to whom he gave the title of Defender of the Faith —taken away later), and pointed out the errors in the calendar, telling him that the moon was five days old when the church calendar said it was only one, and that this error was known not only by the Church, but also by the perfidious Jews and other heretics who laugh about it, and exhorting his majesty in the Lord to send his most famous theologians and astronomers to the council to devise an adequate remedy, so necessary, and bring the matter at last, with the Lord's aid, to a final decision. Nothing was done, however, the reason being given by Copernicus, who, during the council, was asked for his opinion on the subject. In the dedication to Pope Paul III of his work "On the Revolution of the Heavenly Bodies," published in 1543, Copernicus says:

> "For not a great while ago, under Leo Tenth, when the question of reforming the Ecclesiastical Calendar was discussed in the Lateran Council, it then remained undecided merely because the length of the year and months and the motions of the sun and moon were thought to have been not as yet sufficiently determined. Since that time I have directed my attention to observing these more accurately, spurred on by a most illustrious man, Paul, Bishop of Fossombrone, who was then in charge of the matter."

During the Council of Trent, which began its sessions in 1545, Pitatus of Verona submitted a plan for correcting the calendar in which he proposed something new. According to the astronomical tables long in use, the difference between the Julian and the tropical year amounted to one day in 134 years, and Pitatus observed that the omission of three days in 400 years would be practically the same as omitting one day every 134 years. He therefore proposed that three centurial years in every period of four centuries should be common years. His plan was to make the years 1600, 1700 and 1800 common years, 1900 leap year, 2000, 2100 and 2200 common years, 2300 leap year, and so on. He further proposed to restore the equinox to the day on which it fell when the Julian calendar was established by the omission of fourteen days, the seven months containing thirty-one days to be reduced to thirty days each for two years.

Pitatus also recommended the correction of the lunar cycle, and while his plan was a little complicated, it practically amounted to omitting one day from this cycle every 304 years, as had been proposed a number of times before. The lunar cycle was a period of 19 years, containing 235 lunar months, after which the new and full moons returned to the same day of the year, and this cycle was used by the Church in determining the date of Easter. But 19 Julian years exceed 235 lunar months by about an hour and a half, and this excess amounts to one day in 304 years. In the Church calendar the agreement was considered to be exact, and the new and full moons were indicated as

recurring, after a lunar cycle, at precisely the same times, and, therefore, after 304 years the astronomical new moon occurred one day earlier than the new moon of the calendar. Since the Nicene Council over twelve hundred years had elapsed, and the calendar moon had fallen behind four days and more, as the Pope informed Henry the Eighth, and to enable it to keep pace with the moon of the heavens Pitatus proposed to shorten its course, or to omit from the lunar cycle, at stated intervals, enough days to equalize the times of revolution of the calendar and the celestial moon.

The Council of Trent, which came to an end in 1563, considered the question of the reform of the calendar, but charged the Roman Pontiff with its accomplishment. One of the members of this council became Pope in 1572 under the name of Gregory XIII, and during his reign the work was undertaken and carried to completion, and the calendar called the Gregorian.

A commission was appointed to consider all matters connected with the reform, among the members being Cardinal Sirleto of Calabria, named as president; Clavius, a German, who later wrote a large work explaining and defending the new calendar; the Spaniard Ciacconius, whose learning was so great that he was called the Varro of his age, and Ignatius Dante, a Dominican friar, who constructed a meridian line and gnomon to give the Pope ocular proof that the equinox came on March 11. The commission, after examining various plans submitted to it, gave the preference to one that had been worked out by a Calabrian named Lilius, and this was sent, in 1577, to the Christian Princes and most celebrated universities for their approval or amendment. Two methods were suggested for restoring the equinox to March 21 if this date should be decided upon: First, by having no leap years until a sufficient number of days had been dropped; second, by the omission of ten days at one time in the year 1582. The letter transmitting this plan of reform concluded as follows:

> "Deliberate, therefore, mathematicians, who are trained by the contemplation and meditation of celestial things, and with your whole mind and care engage in this common cause, and diligently examining and considering the matter, either approve this plan proposed by Lilius or candidly make known one that may seem to you better, and be pleased to communicate with us. For it will be shameful to us all to longer allow Christians to remain in a grave error and in ignorance of the greatest things. The opinions of Princes and of your learned men will therefore be expected, and the plan that appears most suitable and convenient to the greater part of them, the Pontiff will approve and follow as the highest judgment of the whole Christian world."

A summary of the replies received is given by Kaltenbrunner. The theologians of the University of Paris desired no change at all made. They preferred to let matters remain as they were rather than have the calendar reformed by astronomers who were believers in astrology. Some of those who had proposed methods of reform were noted as astrologers, as the German Stœffler, whose work on the calendar was

published in 1518, and Cardinal d'Ailly, a former Chancellor of the University of Paris, whose work on astrology was well known, a copy of the edition of the year 1490 being in the Library of Congress.*

Fabricius, professor of mathematics in the University of Vienna, gave an opinion on the subject. He approved the reform, but was opposed to correcting the lunar cycle, preferring to abandon all cyclic reckoning for astronomical calculation. He did not approve the introduction of the reform over a period of forty years, and also believed that the omission of a number of days at one time would cause too great confusion in worldly matters and too great a disturbance of the Church year, and advocated the shortening of the various months in the year in which the change was made. He could not understand why they should wait until the year 1582 to carry out the reform and proposed the year 1580, for the sooner it was made the better. He also advocated the omission of thirteen days, as it would be much more appropriate to restore things as they were in the time of the beginning of the Roman monarchy and the Christian Church.

The replies received differed widely, no two agreeing, and Hagen says that almost every imaginable proposition was made except the abandonment of the seven-day week. The commission, therefore, took its own counsel and adopted the plan of Lilius with some changes. It decided to restore the equinox to March 21, the reason being given by Clavius, the leading member of the commission, the expounder and defender of the calendar. In his work, published in 1603, he says:

"Since the greater part of the martyrs, teachers, confessors and virgins, whose festivals the Church piously celebrates in grateful remembrance, lived about the time of the Nicene Council, the martyrs a little before under Decius and Diocletian, most cruel persecutors of the Church of God, the confessors in the time of the Council, or a little after in the times of Basel, Gregory Nazianzus, Chrysostom, Ambrose, Augustine, Jerome, Leo, Gregory the Great, and when lived the recluses of Egypt, the monks of Palestine, and the anchorites under the hermits Anthony and Hilarion, it would not be possible to restore the equinox to a more appropriate time than its time when the Nicene Council was held, in order that the days of the festivals of the saints may recur and be celebrated yearly at the proper time; that is, not far from its place when they lived on earth and made the Catholic Church illustrious by teaching and example. For if it were restored to its place at the birth of Christ, or retained where it was found before the correction, the times of all these saints would be disturbed and disarranged."

The commission made its report in 1580, on the day of the Exaltation of the Holy Cross (which is given in the Church calendar as Septem-

*Stoeffler, finding that a conjunction of Mars, Jupiter and Saturn was to take place in the sign of Pisces in 1524, predicted that a great deluge would overwhelm the world at that time. The prediction caused great alarm and the price of boats went up, a Frenchman of Toulouse constructing an ark in which to escape in the manner of Noah, but that year turned out to be unusually dry. Paul of Middelburg (prominent in the Lateran Council), in order to tranquillize the people, published a book in 1523, dedicated to Pope Clement VII, in which he maintained that no flood would occur the next year, but that on the contrary there would be less rain than usual. This prediction, fulfilled as it was, brought him great fame and honor.

ber 14), and recommended the omission of ten days in the month of October, 1581. This was not done, however, as the Papal Bull, abolishing the old calendar and directing the adoption of the reformed one, was not issued until early in 1582. A translation of this is in part as follows:

"Approval of a calendar recently restored for celebrating the festivals of the Holy Roman Church at their proper time, and also for reciting the divine offices, and abolition of the old calendar. Pope Gregory XIII, servant of the servants of God, for perpetual remembrance of the matter.

Among the weighty cares of our pastoral office, that is not the least which, reserved to the Apostolic See by the sacred Council of Trent, has been brought, God helping, to the end desired.

1. The fathers of this Council, although to their other meditations they added the care of the Breviary also, nevertheless, as lack of time prevented action, referred the whole matter, by decree of the Council, to the authority and judgment of the Roman Pontiff.

* * * * * *

5. When, therefore, we turned to this study and care, a book was brought to us by Antonius Lilius, doctor of arts and medicine, which his late brother Aloysius had written, in which by a new cycle of epacts invented by him, conforming to the established rule of the golden number and adapted to the length of the solar year, all of which is arranged in the calendar in a system to last for all ages, he was able to make the correction in such a way that the calendar seemed to be set forth for posterity without any change. This new and comprehensive plan for correcting the calendar we sent a few years ago, in a small volume, to the Christian Princes and most celebrated universities, in order that a matter which is common to all might be accomplished by the common counsel of all. When they replied concurring, which we greatly desired, induced by the consent of all, we summoned to the fostering city, for the correction of the calendar, men the most skilled in these matters, whom long before we had delegated from the first nations of the Christian world. They with much time and care devoted themselves to this study, and selecting and examining cycles, both old and new, which they diligently compared, by their own judgment and that of learned men who have written of this matter, they chose, in preference to others, the cycle of epacts, some even adding that it seemed, after thorough consideration, to be especially suitable for the perfecting of the calendar.

6. Considering, therefore, that three things are required to be joined together and established for the right celebration of the festival of Easter according to the sanctions of the holy fathers and of the ancient Roman Pontiffs, especially Pius and Victor First, and also of the great Ecumenical Nicene Council and of others: First, a fixed place of the vernal equinox; second, the correct position of the fourteenth day of the moon which falls either on the day of the equinox or next follows it; lastly, the first Sunday which follows the same fourteenth of the moon,—we wish not only to restore the equinox to its former position, from which it has receded about ten days since the Nicene Council, and to bring back the paschal moon to its place of that time, from which it is distant more than four days, but also to provide a plan by which hereafter the equinox and the fourteenth of the moon shall never be removed from their proper place.

7. Therefore, that the vernal equinox, which by the fathers of the Nicene Council was established at the twelfth of the calends of April, may be restored to that place, we direct and command that from the month of October, in the year 1582, ten days be omitted, from the third day before the nones to the day before the ides, inclusive, and the day which follows the feast of Saint Francis, accustomed to be celebrated on the fourth day before the nones, be called the ides of October. . . . . .

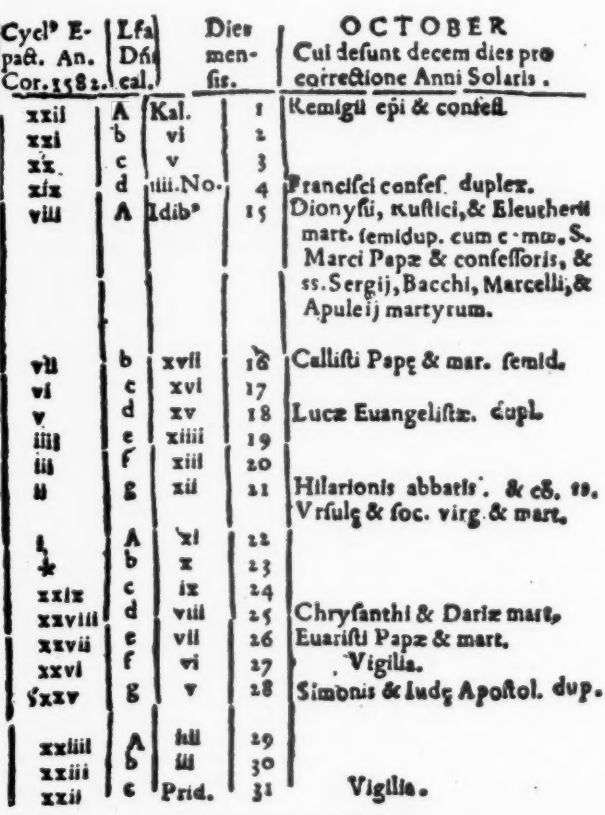
9. In order that the equinox may not again recede from the twelfth of the calends of April, we direct that every fourth year continue to be bissextile (as is the custom) except in centesimal years, which formerly were always bissextile and which we wish the year 1600 to be. After it, however, the centesimal years which follow successively shall not all be bissextile, but in every 400 years the

first three centesimal years shall not be bissextile, but every fourth centesimal shall be a bissextile year. Thus the years 1700, 1800, 1900, are not to be bissextile. In the year 2000, however, according to the custom, a bissextile day is to be intercalated, February containing 29 days, and the same order of omitting and intercalating the bissextile day every 400 years shall be observed perpetually.

12. We, therefore, as a matter which belongs to the Sovereign Pontiff, by this our decree confirm and approve the calendar, now corrected and perfected by the boundless graciousness of God toward His Church. . . . . .

17. To no man, therefore, is it permitted to disobey this page of our precept, mandate, statute, will, probation, prohibition, sublation, abolition, exhortation and rogation, or even with rash daring to oppose it; but if any one should venture to attempt this, let him incur the indignation of the omnipotent God and of His Blessed Apostles Peter and Paul.

Dated at Tusculum in the year of the Incarnation of our Lord one thousand five hundred eighty-first, the sixth of the calends of March, of our Pontificate, year ten."



Cycl' Epact. An. Cor. 1582.	Lfa Dñi cal.	Dies mensis.	OCTOBER Cui desunt decem dies pro correctione Anni Solaris.
xxii	A	Kal. 1	Remigii epi & confess.
xxi	b	vi 2	
xx	c	v 3	
xix	d	iiii. No. 4	Francisci confes. duplex.
viii	A	Idib' 15	Dionysii, Rustici, & Eleutherii mart. semidup. cum c-mo. S. Marci Papæ & confessoris, & ss. Sergij, Bacchi, Marcelli, & Apulei j martyrum.
vii	b	xvii 16	Callisti Papę & mar. semid.
vi	c	xvi 17	
v	d	xv 18	Lucæ Euangelistæ. dupl.
iiii	e	xiiii 19	
iii	f	xiii 20	
ii	g	xii 21	Hilarionis abbatis. & cõ. ꝛc. Vrsulę & soc. virg. & mart.
i	A	xi 22	
*	b	x 23	
xxix	c	ix 24	
xxviii	d	viii 25	Chrysanthi & Dariæ mart.
xxvii	e	vii 26	Euaristi Papæ & mart.
xxvi	f	vi 27	Vigilia.
xxv	g	v 28	Simonis & Iudę Apostol. dup.
xxiiii	A	iiii 29	
xxiii	b	iii 30	
xxii	c	Prid. 31	Vigilia.

PAGE OF AN OLD CALENDAR.

The year of the Incarnation began March 25, and the date is therefore February 24, 1581. In the year beginning January 1, the date is February 24, 1582. It is somewhat curious that in the edition of the Papal Bulls published in Rome in the eighteenth century, the date of this one directing the adoption of the reformed calendar is given in the margin as February 13. Those in charge of the publication could not have understood the meaning of the words sexto calendas Martii (the sixth day before the calends of March). This incorrect date has misled some writers, the German historian Ranke, in his History of the Popes, giving the date as February 13, and quoting as his authority the publication mentioned above, Ranke evidently not reading the date at the end of the papal decree, but taking the wrong date given in the margin.

A page of a calendar published in Rome in 1582, containing the month of October, is shown in facsimile, that month having but twenty-

An Old Medal.

one days. There was no interruption in the days of the week, Thursday, October 4, being followed by Friday, October 15. It will be noted that the dominical letter changed after the omission of the ten days. The dominical letter for 1582 was G, October 1 was on Monday, and the following Sunday was the seventeenth, opposite which is C which became the dominical letter for the remainder of the year.

To explain the method of correcting the Ecclesiastical Calendar by means of the cycle of epacts and their use in finding the date of Easter would be a tedious and difficult task. In some of the replies to the papal letter sent out in 1577, it was suggested that Easter be celebrated on a fixed Sunday in the year, instead of making it a movable feast depending on a fictitious moon, but Clavius said, in discussing this matter, that a custom so ancient ought not to be changed without grave reason. And he computed the dates of Easter until the year 5000, according to both the Gregorian and the Julian calendar, thus relieving any one else of the labor of doing it or of understanding his explanations.

To commemorate the reform of the calendar a medal was struck, a cut of which is annexed. On one side is seen the Pope in his pontifical robes, Gregorius XIII, Pontifex Optimus Maximus (best, greatest Pontiff), and on the reverse the head of a ram, Aries, the sign the sun enters at the vernal equinox, with the inscription anno restituto MDLXXXII (restored in the year 1582). Encircling the medal there is figured a serpent biting its tail, which symbolized, among the ancient Phoenicians, the universe nourished by its own substance and revolving by its own power,* but which in later times became the emblem of eternity, the circle having neither beginning nor end.

In the work of Sacro Bosco previously mentioned, published in 1551, there is a picture of a serpent devouring its tail, representing the revolving year, with the following lines:

Serpens annus ego sum, Sol sic circinat in quo:
Qui fluxit pridem, status est nunc temporis idem.

(A serpent, I'm the circling year
In which the sun turns ever;
And though "time rolls his ceaseless course,"
Time's state is changing never.)

(*To be continued.*)

Washington, D. C.

MOTION OF A PARTICLE ABOUT A CIRCULAR DISC.

F. J. B. CORDEIRO.

In a first survey of celestial mechanics the supposition is made that all bodies attract as if their masses were concentrated in their centers of inertia, or they are regarded merely as material points. If these bodies were composed of homogeneous concentric spherical layers, this would be strictly the case, and if the distances between them were very great, it would be nearly true. But since all celestial bodies rotate and thereby acquire an oblateness of figure, they do not attract like weighted points, but like homogeneous circular discs. For, if we suppose that layers of equal density in these bodies are confocal ellipsoids of revolution, as they very nearly must be, it is readily proved that a homogeneous disc having a radius equal to $\sqrt{\frac{4}{5}}$ the focal distance of the ellipsoid, and of equal mass, will exert nearly the same attraction at all external points. The most important, and in fact the fundamental, prob-

*Macrobius I, 9.

lem in celestial mechanics is therefore the motion of a particle about a circular disc, since these are the conditions under which practically all motions in the universe take place. When the distance between two attracting bodies is considerable, the peculiarities of this motion are masked. The motion is nearly the same as that about a material point. But when the distance is small, its characteristics become strikingly apparent.

It was early noted that all the nearer satellites of our system revolve in the equatorial planes of their primaries in nearly perfect circles, but it excited only a languid interest among astronomers. There seems to have been an idea that it was probably "one of those cases in gravitation," but beyond this their curiosity did not lead them.

Prof. C. A. Young says, "Laplace and Tisserand have shown that the equatorial bulge of a planet, due to its axial rotation, compels a near satellite to move nearly in the equatorial plane. The more distant satellites, like the moon and Japetus, on the other hand, move nearly in the orbital plane of the planet." And again, "Tisserand has recently shown that the equatorial protuberance of a planet compels any satellite which is not very remote from its primary to move nearly in the equatorial plane, but the almost perfect circularity of the orbits is not yet explained."*

If the "man in the street" were to have the leading facts of gravitational astronomy explained to him for the first time, his first question would probably be, "But why are these orbits so symmetrically placed, and why are they perfect circles?",for that is one of the most striking visual facts in all the heavens.

It is proved in treatises on mechanics that the action of a circular disc on a particle in any position consists of a force directed towards the center of the disc, together with a tangential force, or couple, which acting along a meridian tends to turn the particle into the plane of the disc, or in the opposite direction. Taking the mass of the particle as unity, the force towards the centre, or the radial acceleration, is expressed by the infinite series

$$r'' = -\frac{M}{r^2} - \frac{F}{r^4} - \frac{F'}{r^6} - \text{etc.},$$

where M is the mass of the disc and F, F', etc. are functions of C and A, the principal moments of inertia of the disc, and of θ the inclination of the radius to the disc. The first two terms of the series are

$$-\frac{M}{r^2} - \frac{3}{2}(C-A)\frac{1-3\sin^2\theta}{r^4}.$$

We shall consider first the motion of a particle in the plane of the

*The Opus Magnum of both these authors bears the title "Mécanique Céleste." I have been unable to find the demonstration Prof. Young refers to in these volumes and therefore it must be in some other of their writings.

disc. Since the force is a central one, the moment of momentum, N, of the particle will be constant The centrifugal force is $\frac{N^2}{r^3}$ and the radial acceleration is given by the equation

$$r'' = \frac{N^2}{r^3} - \frac{M}{r^2} - \frac{k}{r^4} - \frac{k'}{r^5} - \text{etc.},$$

where k and k', etc., are determinable constants.

The radial acceleration completely determines the motion, without regard to the motion in longitude. We have thus reduced the problem to one in unidimensional motion, viz. the sliding backwards and forwards of a particle on a straight line. Taking only the first two terms of the above series, the result will be the ordinary one, where the central attracting body is regarded as a material point. In this case we find that when $r = \frac{N^2}{M}$, there is no acceleration, or, as we shall hereafter say, this is a zero point for the acceleration. Within this distance the action is repellant, while without this distance it is attractional. Integrating, we have

$$\frac{r'^2}{2} = M\left(\frac{1}{r} - \frac{1}{r_0}\right) - \frac{N^2}{2}\left(\frac{1}{r^2} - \frac{1}{r_0^2}\right), \qquad (1)$$

where r' is the radial velocity, and r_0 is a radius from which the particle is dropped from a state of rest. The apses, or points where the radial velocity is zero, are at r_0 and at another point determined by the equation

$$\frac{N^2}{2}\left(\frac{1}{r} + \frac{1}{r_0}\right) = M.$$

By integrating (1) we derive directly Kepler's laws of planetary motion, so that the motion is completely determined.

To investigate the disc motion completely, we should use all the terms of our series, but as an approximation let us employ only the first three terms, or let us investigate the law

$$r'' = \frac{N^2}{r^3} - \frac{M}{r^2} - \frac{k}{r^4}. \qquad (2)$$

There are now two zero points, or two distances at which there is zero acceleration, viz.,

$$r = \frac{N^2}{2M} \pm \frac{1}{2M}\sqrt{N^4 - 4kM}$$

but if $N^4 = 4kM$, the force curve will touch the abscissa at only one point and there will be a single zero point, while if $N^4 < 4kM$, the

two zero points will be imaginary, and a particle dropped from any distance will fall to the disc. Integrating (2), we have

$$\frac{r'^2}{2} = \left(\frac{1}{r} - \frac{1}{r_0}\right)\left[M + \frac{k}{3}\left(\frac{1}{r^2} + \frac{1}{rr_0} + \frac{1}{r_0^2}\right) - \frac{N^2}{2}\left(\frac{1}{r} - \frac{1}{r_0}\right)\right].$$

The body dropped from r_0 will therefore come to rest at a point determined by the equation

$$\frac{1}{r} = \frac{1}{2}\left(\frac{3N^2}{2k} - \frac{1}{r_0}\right) \pm \sqrt{\left(\frac{3N^2}{4k} + \frac{1}{2r_0}\right)^2 - \frac{3M}{k} - \frac{1}{r_0^2}}. \qquad (3)$$

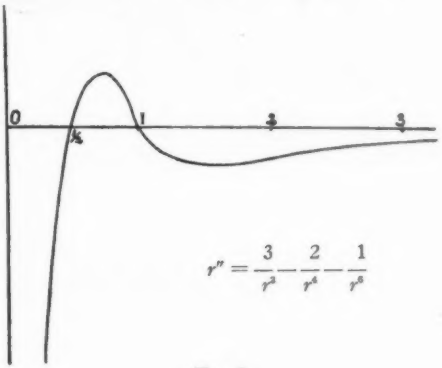


FIG. 1.

Taking the special case under this law of Fig. 1, the force curve is asymptotic to both the abscissa and the zero ordinate and crosses the abscissa at the points $r = 1$ and $r = \frac{1}{2}$.

If the body drops from $r = 2$ it will come to rest at its conjugate point $r = \frac{1}{2}$. Since this happens also to be a point of zero acceleration, the orbit, from this point, will be a circle Equation (3) gives two conjugate points for r_0 and if the radical is real, they will be real, but only one is admissible. One of these conjugate points is for the actual law, while the other is for the case where the forces are supposed to be reversed, or where the gravitational force is supposed to be repellant, while the centrifugal force is supposed attractional. Thus the conjugate of $r_0 = 1$ is 1 and 0.4. Or, with the forces reversed, if the body is let go at $r = 0.4$ it will come to rest at 1, while with the actual forces it will not move. If the radical in equation (3) is imaginary, there will be no real conjugate, or the body will pass through the repellant area and fall on to the disc. This will be the case if the body is dropped from any point beyond 2, but if dropped from any point between 2 and $\frac{1}{2}$, it will continually oscillate between two conjugate points on opposite sides of 1, one in an attractive area, the other in a repellant area.

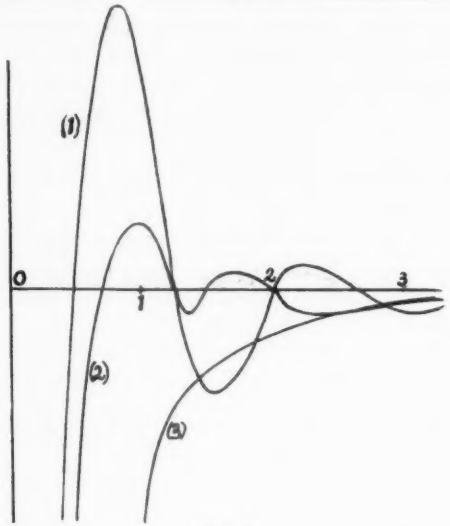


FIG. 2.

Fig. 2 represents the force curve for three different laws.
(1) is for the law

$$r'' = \frac{5}{r^3} - \frac{2}{r^2} - \frac{1}{r^4} - \frac{1}{2}\cdot\frac{1}{r^5}.$$

(2) is for the law

$$r'' = \frac{4}{r^3} - \frac{2}{r^2} - \frac{1}{r^4} - \frac{1}{2}\cdot\frac{1}{r^5}.$$

(3) is for the law

$$r'' = \frac{3}{r^3} - \frac{2}{r^2} - \frac{1}{r^4} - \frac{1}{2}\cdot\frac{1}{r^5}.$$

The last curve nowhere touches the abscissa, showing that a body dropped from any distance will fall continuously on to the disc. Taking the law

$$r'' = \frac{N^2}{r^3} - \frac{M}{r^2} - \frac{k}{r^4} - \frac{k'}{r^5}$$

we have for the conjugate of r_0 a value determined by the equation

$$\frac{N^2}{2}\left(\frac{1}{r}+\frac{1}{r_0}\right) = M + \frac{k}{3}\left(\frac{1}{r^2}+\frac{1}{rr_0}+\frac{1}{r_0^2}\right) + \frac{k'}{5}\left(\frac{1}{r^4}+\frac{1}{r^3r_0}+\frac{1}{r^2r_0^2}+\frac{1}{rr_0^3}+\frac{1}{r_0^4}\right).$$

This equation may have four real roots depending upon the amount of moment of momentum relatively to the other coefficients, but only two apply to the actual forces. The body, therefore, falling from an outside

point may be stopped in the first repellant area, or it may pass through this and be stopped in the second and from this conjugate oscillate to its original level. There are two zero points of acceleration, and if the conjugate should happen to coincide with one of these, the orbit will immediately become circular. If the first repulsional area does not stop the body, it will at least greatly retard it, so that the radial velocity is subject to considerable fluctuations. If the two repulsional areas do not stop it, it will fall on to the disc.

The actual law is represented by an infinite series and has an infinite number of roots, or points of zero acceleration. These may all be imaginary, in which case the body falls continuously on to the disc, or

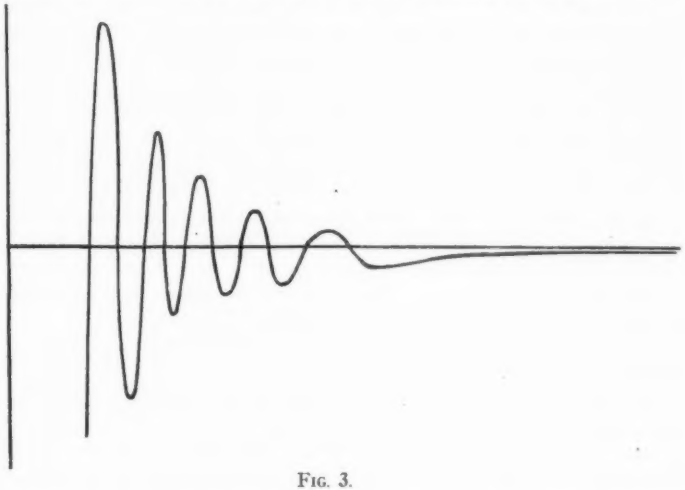


FIG. 3.

they may all be real, or part real and part imaginary. Fig. 3 represents diagrammatically the actual law. With a sufficient amount of moment of momentum there will be an infinite number of real roots. These loops crowd together as we approach the centre of the disc and the intensity of the alternating areas of attraction and repulsion correspondingly increases while their width decreases. The body falling from some outside point may oscillate between that point and any one of an infinite number of conjugate points, but the conjugate point must lie in a repulsional area. The exact conjugate of any given distance depends upon the moment of momentum of the body. If the oscillations are performed near the attracting body, the oscillating body will have to cross a great number of zero points and the chances that the conjugate point coincides with one of these zero points is correspondingly increased. If it is caught on one of these points, the orbit thereafter becomes circular. For a given moment of momentum there is always a

limiting distance, outside the loops, where the curve is simply asymptotic to the abscissa. The oscillation may take place between an outside point and some point in any of the repulsion areas, or between two points in any opposite areas, or in two adjacent areas.

Let us suppose that a satellite has got caught at a zero point, or near a zero point, so that it revolves in a perfect circle or has only a slight oscillation between two adjacent areas. Its motion will be stable but it will possess an unstable kind of stability. A slight disturbance, such as the perturbation of an adjacent satellite, will jar it out of its position. If its moment of momentum is decreased it will slip down an area or so, while if it is increased it may fall out an area or so, but since the areas increase in width as we recede from the primary, a perturbation of a given amount would, on the whole, cause a greater fall inward than it would outward. Or, in general, a certain number of perturbations of average amount, acting in both directions, would cause the body to fall inward. We may say, therefore, that while a single near satellite would be perfectly stable in its circular orbit and would maintain its distance indefinitely, the disturbances from neighboring bodies would tend continually to shake it down on to its primary. In all probability, therefore, the satellites of Mars are now much nearer than they have been in former times, and in the same way the rings of Saturn are probably slowly raining down upon the planet.

The Russian astronomer, Struve, believed that he had observational evidence that the crêpe ring is gradually spreading inward. A body revolving in a greatly eccentric orbit *near* its primary would be quickly brought to circularity.

If a body is revolving about a disc in an inclined orbit, then the path cannot be a circle or in fact a plane curve, and this leads us to consider the nature of such a motion. The moment of the tangential force, or the couple tending to turn the radius into the plane of the disc, or in the opposite direction, is expressed by the infinite series

$$G = (a - b\sin^2\theta + c\sin^4\theta - d\sin^6\theta + \text{etc.})\sin\theta\cos\theta,$$

G being the gravitational couple and a, b, c., etc., certain determinable constants which are functions of C and A, the principal moments of inertia of the disc, and r the distance of the body. Thus the first term of the series is

$$\frac{3(C-A)\sin\theta\cos\theta}{r^5}.$$

Taking only the first term as the law, and dropping the body from an inclination θ_0, we find by integrating that

$$\frac{r^2\theta'^2}{2} = a\left(\frac{\sin^2\theta_0}{2} - \frac{\sin^2\theta}{2}\right),$$

where θ' is the angular velocity. Equating θ' to zero, we see that the

motion consists of an oscillation between two conjugate points above and below the plane, viz., $\pm \theta_0$. Taking the first two terms of the series as the law, we find that there are two inclinations for which the couple is zero, viz., $\sin \theta = \pm \sqrt{\frac{a}{b}}$ or on one side of this angle the couple is positive, while on the other side it is negative. Likewise we find that if we drop the body from an inclination θ_0, the conjugate point, where it comes to rest, is determined by the equation

$$\sin \theta = \pm \sqrt{\frac{2a - b \sin^2 \theta_0}{b}}.$$

If $2a = b \sin^2 \theta_0$, the body will come to rest in the plane of the disc and remain there. If $2a > b \sin^2 \theta_0$, there is a real conjugate point which is in a sector of sign opposite to that from which the body was dropped. If $2a < b \sin^2 \theta_0$, the conjugate point is imaginary and the body will simply oscillate between the inclinations $\pm \theta_0$, passing through the minus sectors where it is retarded. In this case θ_0 is its own conjugate.

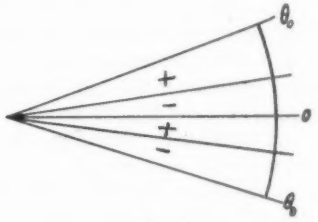


FIG. 4.

For the actual law which is represented by an infinite series, there are an infinite number of roots, or inclinations where the couple is zero. Those zero points crowd together near the plane of the disc. Now the roots of our series may be all imaginary, or they may be all real, or part real, and part imaginary. Likewise for the inclination, θ_0, from which the body starts from rest, the conjugate point may be real or imaginary, that depending upon the value of the coefficients and θ_0. For a given distance there may be an infinite number of real conjugate points corresponding to the infinite number of inclinations from which the body may be dropped, but as the body passes through a great number of zero points, the chances increase that it will get caught at one of them, or that the conjugate will coincide with a zero point.

As in the previous case, it will be seen that any such momentary stability is really unstable and the slightest jar will throw it out of equilibrium, when it will again begin its oscillations. When it comes to rest again the chances always are that it has slipped down to a lower

level towards the plane. It must therefore eventually come to rest in the plane of the disc, where it is in truly stable equilibrium. This result will be attained more rapidly the nearer the particle is to the disc. It may be suddenly attained in a single swing, as in the special case we have previously considered. The problem we have discussed is simply that of a particle starting from rest and oscillating in a vertical plane at a constant distance from the center of the disc. If a satellite is revolving obliquely about its primary the case is similar. We may disregard the motion in longitude and consider only the oscillation in latitude. The body is crossing sectors of force having alternating signs and these are crowded together near the plane, if it is near. It is certain to get caught at some zero point and eventually to slip down to the plane. As in the case first treated there is a limiting distance in any particular case, for any point beyond which there is no real conjugate. If for a given distance the couple is positive at all inclinations, there will be no real zero points. When a planet has a number of satellites, by bringing first the nearer ones into its equatorial plane it thereby greatly extends its disc action outward and is thus able to bring more and more distant ones under its equatorial control. Saturn is considerably oblate and is thus, attractionally, equivalent to a disc of its mass having a certain radius. But Saturn and its rings together are equivalent to a disc of their combined mass and of much greater radius. By adding successively one satellite after another in the same plane, they not only hold themselves firmly together, but are able to bring yet more distant satellites into their plane. Gravitationally, therefore, the four major planets, with their retinues of satellites and rings, are to be treated not as spheres or spheroids, but as discs of great width having the combined mass of the central parts of their systems. The precessional effects upon these large rigid discs must be appreciable, whereas upon the planets alone they would, at such great distances, be very slight.

We can summarize our results as follows:

1. When the attracting body is a material point, a body launched with the slightest moment of momentum can never reach its primary, but will describe an ellipse about it, the eccentricity depending upon the moment of momentum.

2. When the attracting body is a disc, a body launched with a moment of momentum below a certain critical value will reach its primary.

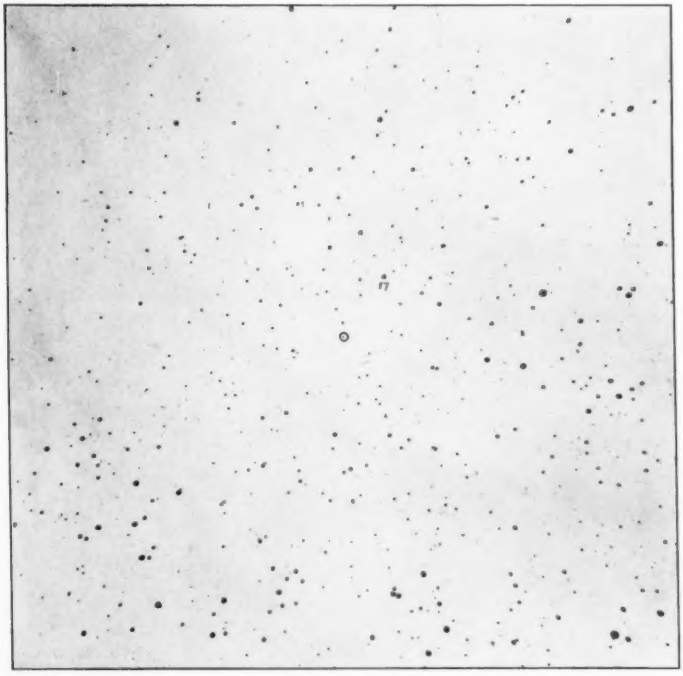
3. A body launched about a disc will tend to assume an orbit in the plane of the disc and this orbit will tend to become circular. If near the disc, this tendency increases. Under certain circumstances a circular orbit may be attained immediately.

4. A body revolving in a circle about its primary in the equatorial plane, and subject only to the attraction of its primary, executes a stable motion and will preserve its distance indefinitely.

5. But subject to perturbations from other bodies, it tends continually to fall inward, and this tendency increases the nearer it is.

PLATE L

NORTH



SOUTH

PHOTOGRAPH OF THE REGION AROUND THE VARIABLE STAR 7428 V CYGNI,

taken with the 2-foot Reflector of the Yerkes Observatory, 1919 June 7. Field 1° square. Limit 15th Magnitude.

In the foregoing we have disregarded tidal action. It can be readily demonstrated that an aggregation of bodies like our solar system must inevitably be finally reduced to two bodies by tidal action. There are therefore two causes working continually towards the consolidation of the system, viz., tidal action and disc action. The rings of Saturn and the satellites of Mars are slowly approaching their primaries. Phobos is accelerating the rotation of Mars and it can only do this by falling inward—tidal action. Deimos is perturbing him and thus aiding his fall by disc action. Phobos therefore appears to be the next candidate for a fall, outside of the little bodies that are constantly grazing Saturn's equator.

Venus and Mercury may originally have had a satellite or satellites, but, if so, tidal and disc action must long ago have brought them down. In any case their absence is perfectly accounted for.

During the last century, Laplace and Lagrange furnished the solar system with a certificate of immortality, which has been called the "Magna Carta of the Solar System." They proved beyond peradventure that the system was an example of stable perpetual motion, and could never by the interaction of its parts commit suicide.

It is said that many dear old ladies and certain timorous persons have drawn much comfort from the assurance of these illustrious geometers and he indeed would be a heartless astronomer who could vouchsafe to inform them that the demonstration was true—provided only that our system consisted of material points. The actual system must go the way of all cases of fancied immortality.

AN INTENSELY RED VARIABLE STAR.

J. A. PARKHURST.

The variable star 7428 V Cygni, whose position for 1900 is

R.A. $20^h\ 38^m\ 5^s$, Dec. $+47°\ 47'$,

proves to have an intense red color. It is on the proper-motion program for the 2-foot reflector of the Yerkes Observatory, but it did not show on the early plate taken 1907 June 20. It was found bright 1919 May 14, and it position was measured relative to the $12^M.9$ star $1'\ 17''$ north, which is number 63 on the catalog sheet of Hagen's *Atlas Stellarum Variabilium*. A photograph taken 1919 June 7 with the 2-foot reflector shows the variable about $0^M.4$ fainter than Hagen 63, therefore $13^M.3$ photographic. On the same night it appeared to the eye as bright as Hagen 17, which is rated as $9^M.7$. The difference between these

values which is now called "color-index," is $3^{M}.6$, about double the color-index of the average long-period variable.

The accompanying chart is reproduced from the photograph of 1919 June 7, and shows the field 1° square around the variable, which is indicated by the small circle. The engraving shows the stars down to about magnitude 15 and is on a scale of 35″.4 to one millimeter. This is a specimen of the 200 variable fields of which charts can be furnished for the use of observers.

THE FLASH SPECTRUM OF JUNE 8, 1918.

H. C. WILSON.

[*Continued from page 436.*]

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	
						1*Nd*?	5432.753	Mn
		0	5432.91	3	5433.10	2	5433.160	Fe
		1	5433.61	0	5433.85	00*N*	5433.844	
		2	5434.79	5	5434.74	5	5434.740	Fe
		1	5435.66	1	5435.99	2	5436.071	Ni
		0	5436.31	1	5436.52	1	.508	Fe
				1	.83	1	.802	Fe
		1	5437.33	0	5437.40	00	5437.413	
						2	5446.797	Ti
		* 6	5447.27	7*d*?	5447.06	6*d*?	5447.130	Fe
		2	5455.25	8	5455.79	2	5555.671	Fe?
		2	5456.12			4	.834	Fe
		1	5458.21					
				1	5462.75	1	5462.705	Ni
		2	5463.31	2	5463.15	3	5463.174	Fe
				3	.46	3	.494	Fe
		1	5466.68	2	5466.61	3	5466.609	Fe
		1	5474.02	2	5474.09	3	5474.113	Fe
		0	5475.05					
		2	5476.81	2	5476.47	3	5476.778	Fe
				8	.96	5	5477.123	Ni
		2	5477.74	1	5477.91	00	.901	Ti
		0	5479.82					
		1	5482.34	0	5482.05	0	5482.078	
		1	5490.36	0	5490.31	0	5490.367	Ti
		1	5493.31			1	5493.709	Fe

* Broad and hazy; with narrow line extending twice as far.

2	5497.04						
2	5497.92	8	5497.61	5	5497.735	Fe	Lumpy
1	5499.12						
1	5501.72	5	5501.67	5	5501.683	Fe	
1	5502.88	0	5502.24				
1	5506.86	5	5507.01	5	5507.00	Fe	
1	5508.78	2	5508.76	0	5508.625		
				0	.840		
1	5510.50	4	5510.16	1	5510.229	Ni	
		2	.82	00	.829		
		1	5512.47	1	5512.470	Fe	
1	5512.74	2	.72	2	.741	Ti	
		1	5513.20	4	5513.198	Ca	
		2	5514.49	2	5514.563	Ti	
2*d*	5515.09	2	.77	2	.753	Ti	
		0	5515.87	0	5515.857		
1	5525.92	2*N*	5525.81	2	5525.765	Fe	
3	5527.34	10	5527.10	3	5527.033	Sc	
3	5528.67	6*d*?	5528.61	8	5528.641	Mg	
1	5530.80	3	5531.01	00*N*	5530.997	Ti	
0	5532.23					Very	Narrow
2	5534.44	8	5535.06	2	5535.061	Fe	
2	5535.53	1	.62	2	.644	Fe	
1	5536.75	0	5636.52				
0	5537.81	1	5537.95				
		0	5538.71	1	5538.738	Fe	
1	5539.08	0	5539.46	0	5539.507	Fe	
0	5541.20						
* 0	5543.42	5	5543.42	2	5543.414	Fe	
		1	5544 21	2	5544.157	Fe	
* 0	5546.18	0	5546.77	2	5546.732	Fe	
1	5548.77						
1*d*	5559.42	0*d*	5559.00				
		0	.93				
0	5565.80	5	5565.92	3	5565.931	Fe	
0	5567.29	3	5567.58	2	5567.621	Fe	
0	5568.85						
0	5569.65	6	5569.91	6	5569 848	Fe	
0	5570.99						
0	5571.90						
		7*d*	5573.08	6	5573.075	Fe	
1	5573.59			1	.328		
2	5576.48	4	5576.29	4	5576.320	Fe	
3	5587.53	5	5587.04	7	5586.991	Fe	
		1	.80	1	5588.084	Ni	
		2	5588.07				
3	5588.95	4	.95	6	5588.985	Ca	
1	5590.50	1	5590.31	3	5590.343	Ca	
0	5599.10	4	5598.64	4	5598.711	Ca	
		1	5599.75				
1	5600.89	2	5600.45	0	5600.450	Fe	
		2	5601.52	3	5601.505	Ca	
1	5602.52						
		5	5603.13	3	5603.083	Ca	
1	5604.04			4	.186	Fe	
0	5604.49						
1	5605.55						

* At edge of band

0	5609.25					
0	5610.79	0	5610.35			
2	5615.99	8*d*	5615.87	6	5615.877	Fe Ragged
1	5617.57	1	5617.44			
0	5619.33	1	5618.87	1	5618.858	
		1	5619.85	0	5619.824	
		3	5624.76	4	5624.769	Fe, V
2*d*	5625.20	2*d*?	5625.61	0	5625.541	Ni
1	5627.61	1	5627.82			
				1	5655.395	Fe
1	5655.69	4*d*	5655.62	2	.715	Fe
2	5657.97	5	5658.06	2	5658.097	Y,-
		3	.50	0	.561	
2	5659.11	2	.88	4	5659.052	Fe
1	5663.22	3*N*	5663.15	1	5663.155	Ti, Fe, Y
0	5664.75	1	5664.09	1*N*	5664.218	Ni-Cr
0	5670.99	0	5670.99	0	5671.061	V
				2	5682.427	
1	5682.71	1*d*	5682.63	5	.869	Na
0	5683.94	3*N*	5684.44	0	5684.098	A
				1	.415	
1	5685.11	0	5684.70	4	.710	Si
0	5686.11					
		2	5686.74	3	5686.757	Fe
0	5687.43			0	5687.697	-,A
1	5688.70	1*N*	5688.45	6	5688.436	Na
1	5693.83	2	5693.91	3	5693.865	Fe
1	5695.83	3*d*	5695.11	2	5695.207	Ni
				0	5696.320	La
		2	5701.70	4	5701.772	Fe
1	5702.70			0	5702.543	Cr
		2*N*	5703.78	1	5703.797	V
1	5705.53	0	5705.62	1	5705.688	Fe
1*d*	5708.66	1*d*	5708.46	1	5708.317	Fe
				3*N*	5708.622	Si
1	5711.25	1	5711.15	6	5711.313	Mg
				3	5712.098	Fe
0	5712.64	3	5712.10	2	.357	Fe
				0	.996	Cr
c 6	5876.29	40	5876.42	...	5875.87	He (D_3)
1	5890.14	10	5890.4	30	5890.186	Na
0	5896.43	10	5896.1	20	5896.155	Na

Table II gives a summary of the lines of different intensities identified as representing the various elements, excepting hydrogen and helium. The identifications in most cases were made before Mitchell's results from the 1905 eclipse came to my notice. While entering his results in Table I a few identifications were changed and several were added. Not having access to the tables of Exner and Haschek, nor Kayser's *Handbuch der Spectroscopie*, I have not followed Mitchell's identifications from those authorities, since that can readily be done by anyone who has their tables at hand. Mitchell was able to identify eight more elements than I have put down in the last column of Table

I. The eight additional elements, excepting copper (Cu) are of high atomic weight. Their symbols are *Cu, Pr, Sa, Eu, Gd, Dy, Er, Nh.* I have found by comparison with Mitchell's results that all of these, excepting *Dy* and *Nh*, are represented by five or more lines each in the measures given under Exposure II in Table I.

In Table II the elements are arranged in the descending order of the number of lines measured. The numbers across the top of the table are the estimated intensities of the lines. Below these, in the body of

TABLE II.

ESTIMATED INTENSITIES OF LINES IN THE FLASH SPECTRUM BETWEEN Hθ AND D_1

	Estimated Intensities.										Total	Average
	0	1	2	3	4	5	6	7	8	10	15	Number	Intensity
Element	Number of Lines												
Fe	55	143	73	35	14	8	9	1	1	1		340	1.7
Ti	12	36	26	.8	5	6	3	2	5	2		105	2.3
Cr	20	39	16	10	3	1	1		1			91	1.5
Ni	11	24	16	4	1							56	1.3
Mn	6	15	16	2	3	2	2					46	1.9
Co	6	10	6	4	2			1	2			31	2.1
Ca	4	7	6	2		1	2		1		2	25	(2.2)
V	8	9	3	1			1	1				23	1.3
Zr	2	5	2	4	2	1						16	2.1
La		5	2	4	2							13	2.2
Mg	1	2	1	1	1	2	1		1			10	3.5
Y		2	3	3				1				9	2.7
Sc		2		1	4		2					9	3.7
Na	1	3										4	(0.8)
Zn			3									3	2.0
Ce		3										3	1.0
Nd		2	1									3	1.3
C			1		1							2	3.0
Si		2										2	1.
Al			1	1								2	2.5
Ba									2			2	8.
Sr			1						1			2	5.
Ag			1									1	—
Cd		1										1	—
—	37	60	14	3	3							117	0.9
Unidentified	42	49	1									92	0.6
										Total		1908	

the table, are given the numbers of lines of each intensity. The numerical distribution of intensities is thus shown at a glance, and it is seen at once that the distribution is not the same for the different elements. Iron (Fe), which yields more than one-third of all the lines, has a high maximum number at intensity 1, while magnesium (Mg) has its intensities distributed pretty uniformly from 0 to 8. Titanium (Ti) with 105 lines has its maximum number at intensity 1, but has twice as many strong lines, of intensity 7, 8, and 10, as iron has.

The line marked with a — gives the numbers of lines which agree closely in wave-length with lines for which Rowland gives no identification.

For 92 lines no satisfactory agreement of wave-length could be found without using lines to which Rowland gives intensity numbers 00, 000, etc.

The average intensities given in the last column were obtained by multiplying each intensity number by the numbers in the column below it, summing the products for each substance and dividing the sums by the total number of lines for each substance.

TABLE III.

ROWLAND'S INTENSITIES IN SOLAR SPECTRUM OF LINES REPRESENTED IN THE FLASH SPECTRUM.

	Rowland's Intensities														Total	Average
	0	1	2	3	4	5	6	7	8	10	12	15	20	30+	Number	Intensity
Element	Number of Lines															
Fe	6	40	65	114	92	48	24	10	14	5	1	5	1	1	426	3.8
Ti	10	19	37	26	17	7	3	1		1					121	2.6
Cr	26	22	19	25	10	4	1	1	1						109	2.0
Ni	13	15	21	12	5	1	1								68	1.8
Mn	7	7	15	12	5	5	2	2							55	2.6
Co	6	8	5	3	5		4								31	2.3
Ca			1	11	8	1	1		2				1	2	27	(4.2)
V	5	3	12	5	1	1									27	1.9
Zr	7	5	4	1	1	4									22	1.8
La	6	4	4	2						1					17	1.1
Mg						2	1		1	1		2	1	2	10	14.4
Y	1	1	4	2		1									9	2.2
Sc			1	6	1	1									9	3.2
Na						1	1						1	1	4	15.2
Zn		1		2											3	2.3
Ce	2	2		1		1									6	1.7
Nd	1	1		1											3	1.3
C	1	1													2	0.5
Si				1	1										2	3.5
Al												1	1		2	17.5
Ba				1	1				1						3	5.0
Sr				1					1						2	5.5
Ag				1											1	—
Cd				1											1	—
—	45	41	34	6	2	1		1							130	1.1
													Total		1090	

As in many cases two or more identifications are given for the same line, these averages are somewhat uncertain, and so they are given to only one decimal place. For calcium (Ca) the average is placed in parentheses because the two very strong lines H and K were omitted in taking the average. The result for sodium (Na) is also placed in parentheses because the two strongest lines, D_1 and D_2, are close to the

end of the spectrum on my plate, where the sensitiveness falls off rapidly.

Table III gives a summary of Rowland's intensities treated by exactly the same method as the estimated intensities in Table II. In this table perforce the unidentified lines are omitted, but the total number of lines is greater because many of the lines in the measured spectrum were blends of two or more lines representing the same or different

TABLE IV.

COMPARISON OF INTENSITIES OF LINES AND ATOMIC WEIGHTS OF SUBSTANCES IDENTIFIED IN FLASH SPECTRUM.

Element	Atomic Weight	No. of Lines	Intensity Flash Wilson	Intensity Sun Rowland	Ratio Sun/Flash		Intensity reduced to Rowland's Scale
H	1.0	5	8.2	. . .	. . .		11.7
He	4.0	5	4.8	. . .	. . .		6.9
C	12.0	2	3.0	0.5	. . .		4.3
Na	23.0	4	(0.8)	15.2	. . .		(1.1)
Mg	24.3	10	3.5	14.4	4.1		5.0
Al	27.1	2	2.5	17.5	7.0		3.6
Si	28.3	2	1.0	3.5	3.5		1.4
Ca	40.1	23	(2.2)	(4.2)	. . .		(3.1)
Sc	44.1	9	3.7	3.2	0.9		5.3
Ti	48.1	105	2.3	2.6	1.1		3.3
V	51.0	23	1.3	1.9	1.5		1.9
Cr	52.0	91	1.5	2.0	1.3		2.1
Mn	54.9	46	1.9	2.6	1.4	1.43	2.7
Fe	55.8	340	1.7	3.8	2.2		2.5
Ni	58.7	56	1.3	1.8	1.4		1.9
Co	59.0	31	2.1	2.3	1.1		3.0
Zn	65.4	3	2.0	2.0	1.0		2.9
Sr	87.6	2	5.0	2.3	0.5		7.2
Y	88.7	9	2.7	2.2	0.8		3.9
Zr	90.6	16	2.1	1.8	0.9		3.0
Ag	107.9	1	2.	3.	. . .		(2.9)
Cd	112.4	1	1.	3.	. . .		(1.4)
Ba	137.4	2	8.0	5.0	0.6		11.4
La	139.0	13	2.2	1.1	0.5		3.1
Ce	140.2	3	1.0	1.7	1.7		1.4
Nd	144.3	3	1.3	1.3	1.0		1.9

substances according to Rowland. This does not, however, affect the average intensities very much.

Comparison of the last columns of Tables II and III shows that on the whole my scale of intensities gives lower numbers than Rowland's, and in Table IV I have tried to find a satisfactory factor by which my estimates should be multiplied to make them consistent with Rowland's. Of course one should not expect to be able to do this completely, because the two spectra are of different character, obtained under different conditions, the one being an emission spectrum from the limb of the sun, the other an absorption spectrum from the whole solar surface.

In Table IV the elements are arranged in the order of their atomic weights, these being taken from a table prepared by the International Committee on Atomic Weights and published in the *Journal of the American Chemical Society*, December, 1917. From the numbers in the second column of Table IV it will be seen that the substances represented in the flash spectrum range in atomic weight from 1 to 144.3. The additional elements identified by Mitchell carry this range on to 167. The lines in the flash spectrum are most numerous for the substances having atomic weights between 48 and 60.

THE MINNESOTA PARTY AT FRASER, COLORADO, READY FOR THE ECLIPSE.

The numbers in columns 4 and 5 of Table IV are the same as those in the last columns of Tables II and III rearranged. At first glance there seems to be no relation between the intensities of the lines and the atomic weights and it is evident that some lines are relatively much stronger in the flash than in the solar spectrum, while decidedly the contrary is true of others, notably the lines of magnesium and aluminum.

Column 6 gives the ratios of the numbers in column 5 to the corresponding numbers in column 4, i. e., the factors by which my intensities should be multiplied to give Rowland's. These are quite uncertain where the number of lines is small, but fairly reliable where the number is above 20, or even 10. For the seven substances with the most numerous lines the average of the factors comes out 1.43. Adopting

this as my correction scale-factor I have multiplied the numbers in column 4 by 1.43 and placed the results in the last column. This last column then may be compared directly with column 5.

As a rule it appears that the lines are more intense in the flash than in the sun, the substances showing notably stronger lines being hydrogen, helium, carbon, scandium, strontium and barium,—three light substances and three heavy. Those which yield decidedly less intense lines in the flash are magnesium, aluminum, silicon, iron and possibly sodium,—all of comparatively low atomic weight except iron. Calcium would also fall in this group if I had included the two very intense lines H and K. In the case of iron I was able to study the variation of my scale-factor through all parts of the spectrum photographed and found it to be nearly constant. The factor should perhaps be somewhat larger for the greater intensities.

TWENTY-THIRD MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

(Continued from page 575)

EVIDENCES OF CHANGE IN CORONAL STRUCTURE DURING THE ECLIPSE OF JUNE 8, 1918.

By JOHN A. MILLER.

Some of the most striking features of the corona of June 8, 1918, were the arches that surrounded the various eruptive prominences. The paper had to do with measures of these arches for the purpose of ascertaining, if possible, if any change either in position or form of the arches had occurred during totality. For the purpose of this study Director Campbell of the Lick Observatory put at my disposal a glass positive of a negative exposed from 1 minute 50 seconds to 1 minute 52 seconds from the beginning of totality. This plate was compared with two plates made by the Sproul Observatory expedition located at Brandon, Colorado. One of these plates was exposed for two seconds at the beginning of totality and the other for three seconds at the end of totality. The focal length of the camera used by the Lick expedition is 40 feet; that by the Sproul expedition 62½ feet. The eclipse occurred at Brandon approximately 25 minutes after it occurred at Goldendale. Three arches were measured, the first on the pole side of the pyramid prominence which is about 50° north of the west extremity of the sun's diameter. The second was on the equator side of the southeastern prominence which is 62° south of the west end of the sun's diameter. The third was on the equator side of the skeleton prominence which is 11° south of the east end of the sun's diameter. The meas-

ures were made in this way. The exact center of the sun was established on each one of the plates. A series of vectorial angles was arbitrarily set off and the radius vector to a point on the arch measured on the Lick plates. This radius vector is called ρ'. The same series of vectorial angles was set up on Sproul plates and the corresponding radius vectors measured which were designated by ρ. If $\rho - \rho'$ is positive it would indicate that the arch was receding from the sun. The measures were made by Miss Margaret E. Powell, a graduate student of Swarthmore College, and were repeated several times, the measures being distributed over a period of about three months. There were 101 measures of radius vectors made. In eight of these the $\rho - \rho'$ is negative. In 93 $\rho - \rho'$ is positive.

In interpreting these results one must not be unmindful of the difficulty in these measurements and the consequent uncertainty, though the measures were made with great care. If the measures are exact and if the apparent change of form of the arches is not due to the difference in the exposure of the two plates, these measures would show that the arches had changed during the 25 minutes that had elapsed between the exposure of the Lick and the Sproul plates.

THE MASSES OF THIRTY-TWO VISUAL BINARY STARS.

By John A. Miller and J. H. Pitman.

This paper dealt with the masses of twenty visual binaries whose parallaxes had been determined at the Sproul Observatory. A comparison of these parallaxes with the parallaxes of the same stars obtained by the other observatories, as well as those obtained by Adams, was also presented. This paper will be published in full.

MEASURES OF DOUBLE STARS ON PHOTOGRAPHS.

By Charles P. Olivier.

In March 1918, an extensive paper was prepared by the writer which included measures of all double stars upon our parallax plates, both those formerly known and discoveries. However before this paper went to press the writer left his regular work, due to the war, and was only able to take it up a year later. Since then measures of many other doubles have been made and the original paper revised.

What is here given is a brief résumé of some of the results. The complete results and measures will shortly appear in the *Publications of the Leander McCormick Observatory*. Measures have been made of over 80 double stars and estimates of a few more which are only elongated. It is found that for stars of 3″ separation or over the measures

made on the photographs are equally accurate with the best visual measures, and show absolutely no traces of systematic errors or differences either in angle or distance, when compared with the former. If the magnitude difference is not too great, the same remarks hold for stars down to 2″ separation, and in favorable cases even to 1″.5. We can at times detect elongations which must amount to from 1″.0 to 1″.2, though the images are then blended. While of course stars of equal magnitude make the easiest objects, still objects like ρ Capricorni and β G.C. No. 10881 are among those measured, where the magnitudes are 5 and 10, and 7.2 and 9.7 respectively, as given in Burnham.

The best proof of the value of the photographic measures, however, rests upon a comparison of them with visual measures of known binaries which are in fast motion. Fortunately we have two excellent examples, 70 Ophiuchi and Krüeger 60. For 70 Ophiuchi we have plates for five epochs, 19 in all. The measures for each epoch show most plainly the progressive changes in both angle and distance, and when compared with the best orbits fit in excellently. The separation varied from 4″.51 to 5″.17 during the interval covered. For Krüeger 60 the plates were measured both by Dr. S. A. Mitchell and the writer. This is a much more difficult object, Burnham giving the magnitudes as 9 and 12. Nine plates taken in two epochs were measured by the writer. The separation for these two epochs varied from 2″.03 to 2″.20. The measures made by both of us show plainly the changes in angle and distance, epoch by epoch. They were compared with contemporary visual measures made by Prof. E. E. Barnard with the Yerkes 40-inch, kindly furnished us in manuscript, and no trace of other than small accidently differences can be found. As this is an easy object in a large telescope visually, while rather a difficult one on our parallax plates, it forms an exceptionally good proof that the measures made on the plates are fully comparable in accuracy with visual measures and are free from systematic errors. The scale of the parallax plates is 1 mm = 20″.8. The measures were made in X and Y coördinates and then reduced to angles and distances. We may therefore conclude that with the McCormick 26-inch, if plates are taken under good conditions of seeing, the average double down to 2″ separation can be photographed and accurately measured. For more favorable cases this limit can be put at 1″.5 or even a trifle lower. It is believed therefore that these measures mark a real advance in photographic double-star astronomy, and open up a very promising field for the future.

SHIFTING ABSORPTION AT THE HEADS OF THE BRIGHTER HELIUM BANDS IN THE SPECTRUM OF γ ARGUS.

By C. D. Perrine.

Attention has been called to a quasi-periodic change in the $H\beta$ band of this star.* Subsequent observations fully confirm those changes and

Astrophysical Journal* **47, 52, 1918.

extend them to some of the other hydrogen bands and to helium radiations.

All of the stronger helium emission in the region of spectrum observed has been identified. It is all broad and much of it, perhaps all, divided by absorption as in the hydrogen bands.

The most striking peculiarity, however, is the appearance at about the times of transition of the $H\beta$ band, of absorption lines at the heads of the helium bands 3889, 4026, 4471 and 5016. On March 7 this absorption at 3889 is clearly double and the others so wide as to indicate duplicity also. This absorption at 3889 remained double for several days. Similar absorption has been identified in at least four epochs beginning in August 1917. During the first three of these epochs the displacements show a rapid *increase*. Between May 2 and 14, the displacements increased (on the assumption of motion) from 600 km/sec. to 1300 km/sec. In March and May last these increases became slower toward the ends of the apparitions. At the most recent appearance, in June, of this absorption, a *decreasing* displacement is shown. The displacements of this absorption are proportional to wave-length as in the novae.

This helium head-absorption appears to be independent of the series to which the radiation belongs but to depend in general upon the intensity of the radiation.

Head-absorption has been observed also at the bright bands 465 and 569 in a few cases, but to be nearly if not quite stationary as regards displacement.

The phenomenon of the absorption in γ Argus appears to be similar to that in the novae and suggests a common cause. So far as our present data go motion satisfies the observed conditions better than any other explanation, as is the case also with the novae.

METHODS OF ASTEROID OBSERVATION AND REDUCTION.

By George Henry Peters.

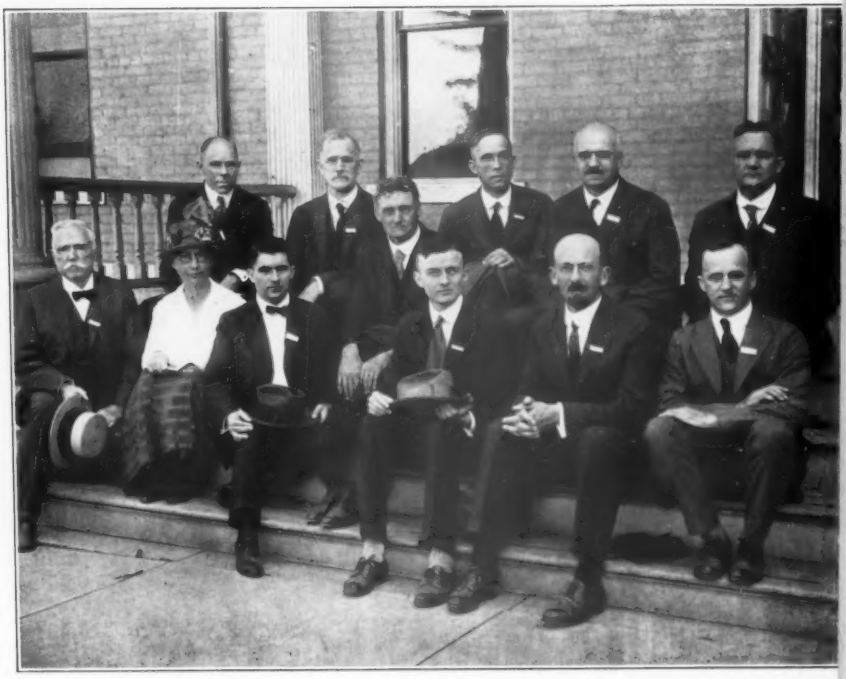
A short description of the photographic telescope and auxiliary apparatus for asteroid observation at the Naval Observatory is given, together with methods for guiding during observations. The importance of a good driving clock, and high power eyepiece, is emphasized, to avoid guiding errors in plates for measurement. A break in the star trails, by capping lenses temporarily, is recommended for long exposures on faint objects. This gives three points of reference on the star trail, with respect to time, provided the asteroid or other body has been properly followed. The effect of differential refraction, atmospheric absorption and dispersion and the coördination of plates used, with color correction of objectives, is discussed. Moonlight interference with asteroid observations, both at full, and near the quarters, and the

PLATE LI

Curtiss Rufus
Kiess Klotz Mrs. Klotz Mrs. Henry Leland Urie
Miss Bigelow
Hussey Albrecht Comstock Henroteau Crump

PRESENT AND FORMER MEMBERS OF THE DETROIT OBSERVATORY STAFF AT THE ANN ARBOR MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

PLATE LII



Brasch Hussey Curtiss Fath Elliot Smith
Comstock
Barnard Miss Glancy Kless Henroteau Stebbins Albrecht

FORMER MEMBERS OF THE LICK OBSERVATORY STAFF AT THE ANN ARBOR MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

effects of sky-glare from the city-lights on the plates is explained. Reference is made to methods employed in search of plates for objects, and to the advantages of twin lenses for detecting spurious images. With superposed plates faint images are intensified, facilitating identification.

The Stackpole measuring engine is described, together with some improvements, also methods of measurement in rectangular coördinates, and the reduction of observations. A one room addition to the office and laboratory building has been erected for this work, with proper lighting for day time measurement of the plates, also for examination and storage of negatives, and facilities for the use of star charts. A criterion of the value of individual asteroid observations is available in orbit computation. The case of (886) Washingtonia is an example, where a series of observations extending over more than four months, discussed by Bower and Wylie, show about the same degree of accuracy for the 26″ equatorial and the photographic telescope of the Naval Observatory, for this class of work. Several stars with proper motions have been detected in the course of the asteroid observations. The status of the asteroid problem in regard to reliable ephemerides, and the desirability of the coöperation of observers, is emphasized. It is desirable to obtain observations of asteroids which have been less frequently observed, especially those with peculiar elements, or subject to extreme perturbations. These are subjects for the consideration of astronomical societies, as well as committees of members selected for special purposes.

THE GREAT ERUPTIVE PROMINENCES OF MAY 29 AND JULY 15, 1919.

By Edison Pettit.

The eruptive prominences of May 29 and July 15 were photographed with the Rumford spectroheliograph attached to the 40-inch refractor. An attempt was made to secure as many plates as possible at quite regular intervals in order to obtain the law of velocity of ascent obtaining during the eruption.

The prominence of May 29 first appeared on the east limb March 22. All returns to the limb were observed except that of April 5. On May 27 and 28 it appeared as a great prominence lying along the limb between latitudes $-41°$ and $-3°$, and rising to a mean height of 150,000 km from two stems located at $-39°$ and $-41°$. On the early morning of the 29th it appeared as a great arch of approximately the same mean height but having parted from one of the stems, and was pouring into a spot at the northern extremity located at latitude $+6°.6$ and longitude $9°.6$.

By 10:10 A. M. the prominence had parted from the stem and was rising with a velocity of 5.5 km/sec. In all 26 plates were obtained cover-

ing a period of $6^h\ 40^m$. The mean height of the prominence was measured on each plate by means of a scale ruled on glass directly to 10,000 km units. These measures were plotted in ordinate with the G.M.T. of the exposures in abscissa. The plotted points represent a broken straight line of four breaks, the velocity being uniform till the break in the line, when it suddenly increases and continues with constant value till another break. The observed velocities were respectively 5.5, 14.7, 27.9, and 60.0 km/sec. The effect was as if the prominence rose with uniform motion, being given impulses at intervals which probably endured only a few seconds, and increased the velocity without disturbing the uniform character of the motion in general.

Knots in the prominence were measured with the stereo-comparator. These measures show that the matter in the prominence was streaming in a long elliptical arc into the spot with velocities which varied from 6.5 km/sec. for points most remote to 130.6 km/sec. for points near the spot at the end of the stream.

The greatest height attained by this prominence was 760,000 km or 17′ from the sun's surface, more than one solar radius.

The prominence of July 15 appeared suddenly the day previously as a low-lying cloud on the eastern limb. The morning of the 15th was cloudy till 10:00 A. M. The first exposure made at 10:08 showed it to be an enormous arch extending from $+11°$ to $-18°$ returning to a spot at latitude $-13°$ and longitude $117°.2$. Its mean height at this time was 200,000 km and velocity 37 km/sec. In $1^h\ 26^m$ it had attained the maximum height of 720,000 km or 16′ from the sun's surface, more than one solar radius.

In all 10 plates were secured. These were measured in the same manner as those of the prominence of May 29, excepting that the settings were made on a narrow rope-like structure passing centrally through the prominence and enduring throughout the ascent. Plotting these measures in the manner previously described it was found that a broken straight line with one break was represented by the plotted points. The velocities were 37 and 163.9 km/sec.

The theoretical height to which these prominences would rise and the time required for the ascent have been computed on the assumption that the prominences were projected into space with the observed velocities and distances from the sun. The following table gives a comparison of this theoretical data and the observed values.

Prominence Height	Velocity	Height Attained at this Velocity	Theoretical Max. Height	Observed Duration	Theoretical Duration
		The Prominence of May 29			
150000 km	5.5 km	50000 km	83 km	164 min.	0.51 min.
200000	14.7	119000	666	133	1.51
319000	27.9	91000	3010	57	3.57
410000	60.0	230000	17059	63	9.53
		The Prominence of July 15			
200000	37.0	294000	4211	43	3.80
294000	163.9	426000	111753	47	23.56

Again the motion of the prominence is uniform for a period, when it suddenly increases in velocity as if given an impulse. In the series of prominence plates at Yerkes there are only two cases of this kind which afford material for these studies. One was taken by Mr. Slocum, March 25, 1910, and the other by Mr. Lee, October 21, 1914. There are 5 plates in the first and 6 plates in the second series. On plotting these measures the same principles of motion are found to obtain as in the case of the two prominences just discussed, the plots representing broken straight lines of one break each.

It seems probable then that eruptive prominences in general obey the following principles of motion.

(1) Before the ascent begins a force opposed to gravitation exerts a pressure against the underside of the prominence, compressing it over a large area.

(2) After the ascent begins the velocity is constant until an impulse increases it.

(3) After the impulse the velocity is constant at the new value until another impulse is received.

It is urged that spectroheliograph observers should attempt to secure material suitable for further studies of this kind on occasions of future eruptions. As to any explanation of the phenomena as described here little can be said at present except that nothing at all satisfactory has been arrived at.

STUDIES IN PROMINENCE CHARACTERISTICS.

By Edison Pettit.

That there is a need of a study of prominence classification on a more rational basis than heretofore cannot be denied. An attempt to approach the subject visually, however, is beset with numerous difficulties, the Rumford plates furnishing on the other hand at the present time a store of information which may be used for this purpose.

During the past year a study of prominences and prominence structure was undertaken with this object in view. Drawings were made of type forms, the prominences on each plate being classified and their positions taken, as well as any possible relation to disk structure. To date, the series of plates contains 7800 of both prominences and the disk, covering the period back to 1903. Those between 1908 and 1916 have been already reviewed and the better plates in the remainder of the series as well. Cases affected by hazy sky or bad definition were culled out so that only those where the structure was clearly discernible were made use of. So far seventy-five drawings have been made of type detail and all the prominences classified under these. Out of this material several interesting types were given special attention.

(1) *Spot Type or Splash Prominences.* These consist of a number

of radiating spikes, often projected in broken lines radially from the spot. Generally in an active spot this is accompanied by one or sometimes two wings, one on either side, one being considerably larger than the other, sometimes lying on the limb—often raised into space. The prominence of May 29 was typical of the latter and the prominence associated with the great spot of August 1917 was typical of the first.

The distribution of these prominences is of course practically the same as that of the great active sunspots of the same epoch. Practically all lie between longitudes 0° and 180°, showing a sharp maximum at longitude 144°. Some 70 of these have been recorded.

(2) *Jets.* These generally also are found in the sunspot areas. Their peculiar curvature, like that of a partially closed ellipse, strongly suggests strong central forces at their origin.

(3) *Tornado Type.* These are generally very small as prominences go, about 16″ (12000 km) diameter and 96″ (70000 km) high. These objects require the best conditions of atmospheric definition to be successfully photographed, and under inferior conditions will appear as a solid column.

The lantern slide illustrates two of them taken in the Rumford series. One was taken by Mr. Slocum, Oct. 15, 1910, and the other by Mr. Biefeld and myself, July 12 of the present year. Now it will be seen that, assuming say, the top of the prominence to rotate, the direction of the rotation can be determined from the slope of the twist in the stem. Thus in the two cases we have here, this twist would be right-handed as may be easily seen. Two cases show these prominences bifurcated. When this occurs the two branches rotate in opposite directions, one branch being right and the other left handed as if they were geared together.

There are 27 of these tornado prominences in the series; 21 (78%) are in the southern hemisphere, clustered principally about latitude —50°. Of these all except two are right handed. One is bifurcated as described above; one is left-handed. Six are in the northern hemisphere. Of these 3 (50%) are right-handed, 1 left-handed, 1 questionable, 1 bifurcated as described above. Hence it may be said that 93% show a right-handed twist, or rotation, under the above definition.

(4) *Prominence Bases.* A number of large as well as smaller prominences show a root-like or claw-like structure at the base where they arise from the chromosphere. This is well shown in the prominence of May 29. When a prominence comes over the limb through a period of several days this structure makes its appearance at the middle of the series, hence we may conclude that the prominence is actually on the limb at that time—thus offering a criterion of limb tangency, as it were. This claw-like structure is often so marked as to make the object appear like a tripod standing on a table. The explanation might be made that the prominence was formed by gases escaping from small orifices in the surface of the photosphere or chromosphere.

(5) *Rockets.* Occasionally this claw-like structure becomes greatly exaggerated, the prominence rising as if driven upward by the force of the jets, if there be such, standing as if on stilts. Finally it breaks away trailing two or three streamers, the former claws, behind it.

(6) *Polar.* Prominences within 10 degrees of the pole, as photographed in the calcium, are generally small, insignificant bodies, spikes and small horn-like objects. No large prominence was found in this region.

It is intended that after the study of prominence structure and phenomena, and their relation to the disk structure, is completed the type forms shall be arranged into types and sub-types, from which these properties may be recognized in prominences which may fall into these classes. This report is intended only as an outline of the progress thus far attained.

THE PROPER MOTIONS AND PARALLAXES OF 359 STARS IN THE CLUSTER *h* PERSEI.

By HANNAH STEELE PETTIT

The original purpose of this investigation was to determine, if possible, the parallax of the cluster *h* Persei ($\alpha = 2^h\ 12^m$, $\delta = +56°\ 52'$) by the photographic method. To do this it would be necessary to know which stars belong to the cluster and which to the background. It was thought that a study of the proper motions over the long time interval of 14 years might enable us to separate the stars of the cluster from the others. The parallaxes of these stars could then be determined with reference to the background. The quantities under consideration are, however, so small and the range of magnitude considerable that it has not yet been possible to make this separation.

The plates used were taken after the manner of those for the regular parallax work with the 40-inch refracting telescope of the Yerkes Observatory. In deducing the proper motions, 4 plates were used, giving an interval of 14 years between pairs, from 1903 to 1917. For the parallaxes 6 plates were used, 3 with positive and 3 with negative parallax factors, extending over an interval from August 1916 to January 1918. The plates are all good and in some cases exceptionally so. The field covered extends from $2^h\ 9^m\ 58^s$ to $2^h\ 13^m\ 56^s$ and from $+56°\ 23'.5$ to $+56°\ 53'.7$; and 359 stars were measured. The scale of the plates is a quarter mm $= 2''.66$.

In order to determine whether it was necessary to retain the second order terms in reducing the constants of the plate, solutions were made for the proper motions in X, using both 6 and 3 constants. Gauss's quantity r was obtained in each case. With 6 constants $r = \pm 0''.075$; while with 3 constants $r = \pm 0''.076$. Thus it is shown that nothing was to be gained in reducing accidental errors by retaining the second

order terms. Moreover, a comparison of the two sets of residuals shows that 76% differ by less than 0.010 (corresponding to an annual proper motion of 0".001); while in only 17 cases was the difference greater than 0.020, the maximum difference being 0.036 (corresponding to an annual proper motion of 0".004). After identifying these 17 stars on the plate, it was found that without exception they fell in the four corners. Thus in the rest of the work the second order terms were neglected.

The following tables give a summary of the proper motions and parallaxes. The values are relative to the "center of gravity" of the system.

Of the 359 proper motions in X there are:

137	between	0".000	and	+0".009	161	between	0".000	and	—0".009
21	"	+ .010	"	+ .019	27	"	— .010	"	— .019
6	"	+ .020	"	+ .029	1	"	— .020	"	— .029
2	"	+ .030	"	+ .039	0	"	— .030	"	— .039
4		greater than		+0".039	0		greater than		—0".039

Of the 359 proper motions in Y there are:

164	between	0".000	and	+0".009	169	between	0".000	and	—0".009
8	"	+ .010	"	+ .019	14	"	— .010	"	— .019
1	"	+ .020	"	+ .029	2	"	— .020	"	— .029
0	"	+ .030	"	+ .039	1	"	— .030	"	— .039
0		greater than		+0".039	0		greater than		—0".039

Of the 359 parallaxes there are:

61	between	0".000	and	+0".009	57	between	0".000	and	—0".009
47	"	+ .010	"	+ .019	34	"	— .010	"	— .019
34	"	+ .020	"	+ .029	42	"	— .020	"	— .029
15	"	+ .030	"	+ .039	15	"	— .030	"	— .039
12	"	+ .040	"	+ .049	15	"	— .040	"	— .049
11	"	+ .050	"	+ .059	1	"	— .050	"	— .059
5	"	+ .060	"	+ .069	1	"	— .060	"	— .069
4	"	+ .070	"	+ .079	0	"	— .070	"	— .079
4		greater than		+0".079	1		greater than		—0".079

THE SPECTROSCOPIC ORBITS AND DIMENSIONS OF THE ECLIPSING VARIABLES U OPHIUCHI, RS VULPECULAE, AND TW DRACONIS.

By J. S. Plaskett.

These three interesting variables have had the elements of their spectroscopic orbits determined at Victoria from spectra obtained from March to July 1919. In U Ophiuchi and RS Vulpeculæ, spectral types B5 and B8 respectively, the second spectrum is visible though faint and difficult to measure. In TW Draconis, spectral type A3, as the brighter star gives nearly ninety per cent of the light of the system, the second spectrum can not be seen and the information about this system is hence not so complete.

The elements of the spectroscopic orbits are as follows:

Element	U Ophiuchi	RS Vulpeculae	TW Draconis
e	0.00	0.053	0.054
K_b	179.8 km	55.0 km	65.8 km
K_f	204.6 km	176.0 km	
γ	—11.5 km	—22.0 km	—0.3 km
ω	0	236°.26	90°.0
T	0	1.903	0.019
$a_b \sin i$	4,147,000 km	3,388,000 km	2,535,000 km
$a_f \sin i$	4,718,000	10,842,000	

From the photometric orbits we obtain the inclination and the radii of the two stars in terms of the semi-major axis of the relative orbit and consequently in U Ophiuchi and RS Vulpeculae, where we know the ratio of the masses, we get the dimensions, masses, and densities of the systems. In TW Draconis the ratio of the masses was obtained from Shapley's empirical formula and these hypothetical dimensions are given with the others in the following table, where the linear dimensions are in terms of the sun's radius and the masses and densities in terms of the mass and density of the sun.

Dimensions		U Ophiuchi	RS Vulpeculae	TW Draconis
a	semi-axis relative orbit	12.82	22.00	13.71
a_b	" " orbit brighter star	5.86	5.24	3.70
r_b	radius brighter star	3.23	2.05	2.47
r_f	radius fainter star	3.23	10.25	4.58
m_b	mass brighter star	5.36	5.40	3.21
m_f	" fainter "	4.71	1.69	1.19
ρ_b	density brighter star	0.18	0.63	0.21
ρ_f	" fainter "	0.16	0.0016	0.0124

A graphical representation of these dimensions is given in the slide where the intersections of the vertical and horizontal lines represent the centers of mass of the system and the series of figures to the left the stars at primary eclipse and to the right at maximum separation. No attempt has been made to represent the elliptical shape of the bodies in this figure.

In RS Vulpeculæ and TW Draconis, where the time of periastron is fairly accurately known, the spectroscopic phase is 3 hours and 27 minutes, respectively, later than the photometric, and of the opposite sign to the discrepancy found by Schlesinger. These quantities seem too great to be due to observational error but it is difficult to imagine a physical cause which would account for a difference of phase in one direction in some instances and the opposite in others.

REPORT ON PROGRESS OF WORK WITH THE 72-INCH TELESCOPE.

By J. S. PLASKETT.

It has seemed best to make a short report on the work of the telescope to the Society, else the number of spectroscopic binary orbits from this observatory on the program might lead to the belief that this was the main work of the institution.

Since the installation of the mirror, fifteen months ago, 2700 star spectra have been obtained. These spectra are mostly of stars from a list of about 800 north of the equator from Boss's Catalogue. This list was arranged in coöperation with Mt. Wilson with the plan that the radial velocities of all the stars in Boss, within reach at the two observatories, would be completed at about the same time.

About 2500 spectra of some 600 of these stars have been obtained at Victoria, of which, owing to the small staff, only about two-thirds are measured. From these measures 80 of these stars have been found to be spectroscopic binaries. It is proposed to obtain at least six plates of each star—eight if the lines are poor—in order that reliable velocities may be obtained with single prism dispersion. As the probable error of a plate in spectral types F or later is less than a kilometer per second, the results should be accurate to half a kilometer.

It is hoped that this program will be completed in less than two years, when the radial velocities and proper motions of about 4000 stars should be determined—an important accession to our knowledge of the motions of the stars.

It is proposed to devote at least two-thirds of the time of the staff to this main program, leaving the remainder for such accessory investigations as the orbits of the binaries discovered here. At the same time, this may also be considered part of the program, as only when the orbit is determined is the velocity of the system known.

THE ANNULAR ECLIPSE OF THE SUN OF 1919, NOVEMBER 22, AS VISIBLE IN THE UNITED STATES.

By WILLIAM F. RIGGE.

Three diagrams showed all the phases of the eclipse, such as the times, the position angles of the points of contact, and the magnitudes for the entire United States, while a fourth showed the appearances of the sun for every tenth of a magnitude and for the annular phase.

DIRECT MICROMETRICAL OBSERVATIONS OF THE SUN. HELIOGRAPHIC POSITIONS OF SUN SPOTS.

By E. D. Roe, Jr.

This paper gives the mathematical treatment of a new method, so far as I am aware, of observing the sun directly with the micrometer. The motive for the work was twofold: (1). To find more daylight work for the telescope. (2). To encourage amateur work in this field, in which, by the method used, the small telescope has the advantage, unless a special eyepiece giving a field of 21′ can be devised for the large refractor. The measurements are all made with the driving clock on. The position circle is set at the position angle of the axis of the sun at the time of the observation and the fixed thread, previously placed in the center of the tube, is brought by the slow motions to bisection of a spot or a point in a spot, and the movable thread run out to tangency with the limb. By subtraction of this measure from the sun's semi-diameter a coördinate x of a conical projection on a plane inclined at an angle to the diametral plane perpendicular to the line to the sun's center is obtained. The position circle is then rotated through 90° and a second coördinate y in the same plane is obtained. The linear unit used throughout is one turn of the screw.

From x and y the orthogonal coördinates x_0, y_0 in the diametral plane perpendicular to the line to the sun's center are obtained and found to be

$$x_0 = \frac{x}{d}\left(\sqrt{(d^2-x^2)}\right)\left[1 - \frac{\sqrt{(r^2-x^2-y^2)}}{\sqrt{(d^2-x^2-y^2)}}\right]$$

$$y_0 = \frac{y}{d}\left(\sqrt{(d^2-y^2)}\right)\left[1 - \frac{\sqrt{(r^2-x^2-y^2)}}{\sqrt{(d^2-x^2-y^2)}}\right]$$

Approximate simpler formulas derived from these and correct to three places of decimals can be used for calculations. In these formulas d is the distance from the observer to the center of the sun, r is the sun's semi-diameter from the observer's standpoint. For d and r the distance from the earth to the sun and the sun's semi-diameter at the time as given by the Nautical Almanac may be used without sensible error. The angle between x_0 and y_0 is theoretically greater than 90°, but its greatest possible theoretical excess over 90° is less than 2″.31, an angle beyond detection with any position circle. The angle is taken as 90° and from x_0, y_0, r and the latitude of the center of the sun's disc, we get two sides and the included angle of a spherical triangle on the sun's surface, whose solution leads to the heliographic latitude and longitude of the spot or point selected for observation. No correction for refraction has been made.

The same method, *mutatis mutandis*, with axes chosen at convenience, can be used to find the distance between two points on the moon, farther spherical and plane triangles requiring solution.

A subsequent paper will be published giving the results of computation for numerous observations on sunspots made by the writer by this method at Roe Observatory with the 6½-inch Clark refractor and Gaertner micrometer.

THE SPECTRUM OF THE MILKY WAY.

By V. M. SLIPHER.

Knowledge of the spectral type and motion of the stars of all magnitudes composing the Milky Way is today an important need in general studies of our sidereal system. Such information for the individual stars of even a few selected regions would have wide application but it would be difficult to obtain, requiring our largest telescope by present methods and much time. It is possible, however, to get information as to the *predominant* spectral type of the integrated light of the stars by treating the Milky Way as a luminous surface, for which only a spectrograph is really essential.

Some preliminary observations in this direction were made at Flagstaff, employing a spectrograph of high light-power and sufficient dispersion to clearly disclose the main features of the different spectral types. Observations were got of two regions; one in Sagittarius and one in Scutum. Lantern slides were exhibited to show the results.

The spectra of the two regions are similar: both have strongly the main features of the solar type spectrum. Closer inspection shows stronger hydrogen lines than belong to that type, and the spectrum would be termed "composite" with the solar light predominant. This result perhaps seems surprising since studies of the brighter stars had suggested that the fainter galactic stars were of the first type. This result is in accord with Fath's who found the spectrum to be approximately solar type.

ALL-AMERICAN TIME.

By ELLIOTT SMITH.

The time-system here suggested was outlined in detail by Professor Porter, Director of the Cincinnati Observatory, in a pamphlet recently published. He designates the proposed system, "All-American Time." In this system it is proposed, (1) that the hour zone system be abolished, (2) that clock dials throughout the United States read the same at any instant of time, (3) that 12 o'clock occur at noon on the 90th meridian, and (4) that the time of legal noon at other longitudes be fixed by proper legislative authority. Professor Porter indorses the suggestion that time be counted through 24 hours, thus eliminating the terms A. M.

and P. M. It is assumed in the system now in use that when it is midday the clock dial must read 12. Readings of 10, 11, 1 or 2 may be used to designate midday quite as well as the number 12. That the time of legal noon for places east and west might differ as little as possible from 12, was the purpose of making 12 the legal noon as the 90th meridian.

PROGRESS IN PHOTO-ELECTRIC PHOTOMETRY.

By JOEL STEBBINS.

This paper gave a discussion of the improvements in the photo-electric apparatus by Dr. Jakob Kunz and myself, and an account of work on bright variable stars.

α Herculis is a well known suspected or irregular variable. In two seasons it has shown a variation of more than 0.3 magnitude, somewhat irregular, but with a quite definite period of 120 days.

σ Aquilae is a new variable with a spectroscopic period of 1.95 days, the spectra of both components being visible. This star is apparently of the β Lyrae type, with a range greater than 0.15 magnitude.

1 H. Cassiopeiae is a spectroscopic binary with period 6.067 days. A primary eclipse of 0.15 magnitude or more was found to take place 0.4 day ahead of the predicted time. This discrepancy may be due to a slight error in the assumed period. The secondary minimum has not yet been observed.

π^5 Orionis was announced as a new variable in 1916. A definitive light-curve has been derived showing the variation to be due to ellipticity of figure of the bodies of the system, and agreeing with the spectroscopic period of 3.70 days. The range of variation is 0.05 magnitude.

λ Tauri is a well known star for which no good light-curve had previously been determined. Contrary to expectation there are no large irregularities. There is a primary eclipse of 0.32 magnitude, a secondary of 0.08 magnitude, and large ellipticity and radiation effects. A special effort was made to detect the presence of the third body of the spectroscopic system, but without success. The complete study of this star will be published in the *Astrophysical Journal*.

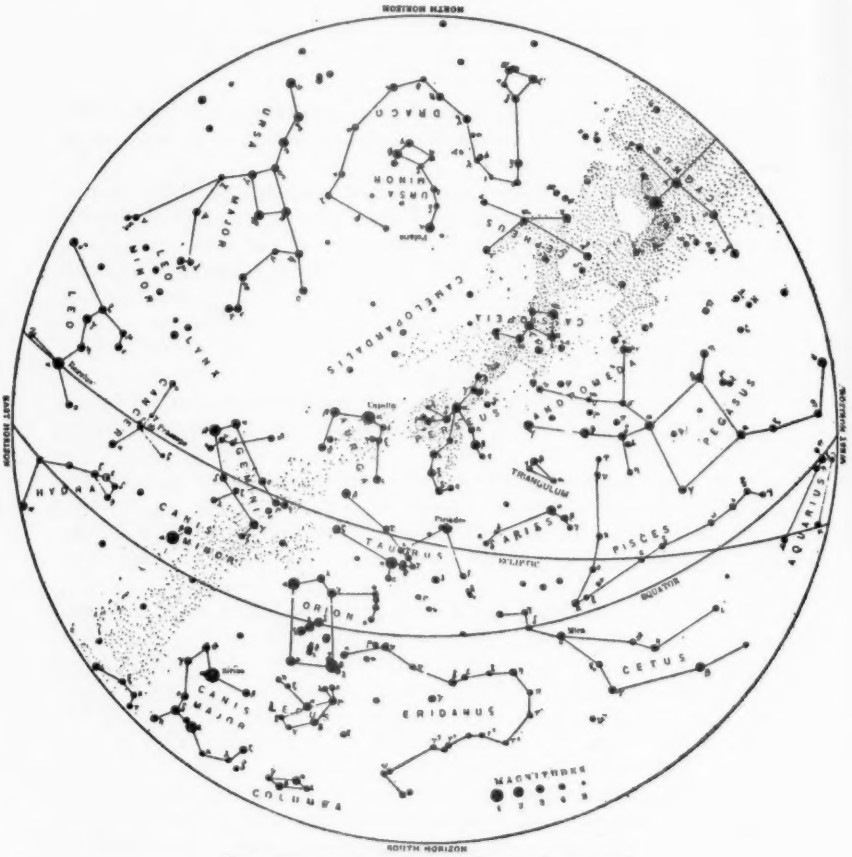
A new departure in our photo-electric work has been the observation of groups or sequences of stars, taking them in rapid succession up to ten or twelve stars, with only a few readings on each. The object is to detect large variations of a tenth of a magnitude or more.

Experiments have been carried on by Dr. Elmer Dershem in the use of audion tubes for amplifying the photo-electric current, and thus to increase the range or accuracy of the photometric measures.

(*To be continued.*)

PLANET NOTES FOR JANUARY, 1920.

The *sun* will change its position from $18^h\ 43^m$ right ascension and 23° 5′ south declination on January 1 to $20^h\ 51^m$ right ascension and 17° 39′ south declination on January 31. It will move from Sagittarius into Capricornus.



THE CONSTELLATIONS AT 9:00 P. M. JANUARY 1.

The phases of the moon for the month are as follows:

Full Moon	Jan.	5	at 3	P.M.	C.S.T.
Last Quarter		12	" 6	P.M.	"
New Moon		20	" 11	P.M.	"
First Quarter		28	" 10	A.M.	"

Mercury will not become visible during this month. It will be receding from its position of greatest elongation west on December 21, and will almost have reached superior conjunction by the end of the month.

Venus will be moving eastward more rapidly than the sun, and will consequently not be found as high in the eastern sky in the morning as it was during December. At the end of the month it will rise a little more than an hour before the sun, and will still be the morning star.

Mars will continue to move slowly eastward. It will be in quadrature about the middle of the month. At this time it will rise at midnight and may therefore be observed in the early morning. At this time it will be a short distance north of the bright star Spica. It will be about 125,000,000 miles from the earth.

Jupiter will be in the eastern sky in the evening. It will be very near opposition at the close of the month. Its apparent motion will be westward in the sky throughout the month. It will be a short distance northwest of Regulus at the middle of the month.

Saturn will be a few hours east of Jupiter. At the end of the month it will cross the meridian about two o'clock in the morning. It will be southeast of Regulus.

Uranus will cross the meridian about two-thirty in the afternoon at the middle of the month. It will therefore be rather low in the southwest at sunset and not in favorable position for observation.

Neptune will be in opposition on January 30. It will move westward about three minutes of time during the month. Its path will lie in the constellation Cancer this month.

Occultations Visible in the United States, January, 1920.

(NOTE:—Geographical positions are indicated by giving for each point, first the latitude, then the longitude, the two being separated by a hyphen. A line drawn on a map through the two or three points thus indicated will mark the limit of the region of visibility. The time given is the Greenwich Mean Time, approximately, of the middle of the occultation as seen from the center of the part of the U. S. where it is visible.)

Jan. 1, $15^h.5$. 53 Arietis, Mag. 6.0. Throughout the U. S. except north of 40° - 124°, 45° - 109°, 48° - 92°.

Jan. 2, $14^h.5$. 43 Tauri, Mag. 5.5. Throughout the U. S. except south of 30° - 170°, 35° - 91°, 37° - 75°.

Jan. 3, 12^h. *l* Tauri, Mag. 5.2. Throughout the U. S.; but west of 49° - 122°, 30° - 105°, the whole occultation occurs before sunset.

Jan. 3, $17^h.5$. 351 B. Tauri, Mag. 6.2. North of 46° - 126°, 48° - 97°, 43° - 70°.

Jan. 4, 0^h. 372 B. Tauri, Mag. 6.1. South of 45° - 124°, 40° - 112°, 34° - 96°, and west of 34° - 96°, 28° - 96°.

Jan. 4, 9^h. 64 Orionis, Mag. 5.1. Emersion visible in Maine just after sunset.

Jan. 4, 12^h. 68 Orionis, Mag. 5.7. Throughout the U. S.; but west of 49° - 119°, 40° - 112°, 28° - 102°, the whole occultation occurs before sunset.

Jan. 5, 20^h. 162 B. Geminorum, Mag. 5.7. Throughout the U. S. except northeast of 45° - 77°, 42° - 71°.

Jan. 6, 10^h. 30 B. Cancri, Mag. 6.1. Emersion visible in eastern part of Maine.

Jan. 6, $17^h.5$. 29 Cancri, Mag. 5.9. Visible in Texas south of 29° - 104°, 28° - 94°.

Jan. 6, 21^h. 84 B. Cancri, Mag. 6.4. Throughout the U. S. except the northeastern part of Maine.

Jan. 7, 3^h. A^2 Cancri, Mag. 5.7. West of 34° - 121°, 49° - 109°. (Farther east the occultation occurs after sunrise.)

Jan. 7, 20^h. ω Leonis, Mag. 5.5. Throughout the U. S.

Jan. 9, 20^h. p^5 Leonis, Mag. 5.3. South of 35° - 119°, 32° - 105°, 28° - 94°.

Jan. 11, $22^h.5$. ψ Virginis, Mag. 5.0. South of 47° - 124°, 40° - 106°, 30° - 88°.

Jan. 12, 19^h. 550 B. Virginis, Mag. 6.0. Northeast of 45° - 74°, 43° - 68°.

Jan. 15, 21^h. ω^1 Scorpii, Mag. 4.3. East of 48° - 92°, 38° - 94°, 29° - 92°, including Florida.

Jan. 15, 22^h. ω^2 Scorpii, Mag. 4.6. East of 49° - 92°, 45° - 94°, 40° - 91°, and northeast of 40° - 91°, 34° - 76°.

Jan. 16, 1^h. 84 B. Scorpii, Mag. 6.3. North of 40° - 124°, 32° - 109°, 28° - 100°; and west of 28° - 100°, 48° - 88°. (Farther east the occultation occurs after sunrise.)

Jan. 16, 3^h. 51 G. Scorpii, Mag. 6.5. North of 45° - 124°, 41° - 114°, and west of 41° - 114°, 49° - 108°. (Farther east, occurs after sunrise.)

Jan. 17, $1^h.5$. 116 B. Ophiuchi, Mag. 6.3. West of 49° - 94°, 38° - 97°, 27° - 100°. (Farther east, occurs after sunrise.)

Jan. 23, 12^h. 51 Aquarii, Mag. 5.8. South of 34° - 119°, 40° - 98°, 42° - 81°, and west of 42° - 81°, 40° - 77°, 35° - 76°.

Jan. 27, 20^h. 12 H^1 Arietis, Mag. 6.3. North of 45° - 124°, 42° - 114°, and west of 42° - 114°, 49° - 102°.

Jan. 28, 17^h. 124 B. Arietis, Mag. 6.4. North of 44° - 124°, 42° - 96°, 37° - 75°.

Jan. 30, 22^h. 333 B. Tauri, Mag. 6.3. North of 48° - 124°, 44° - 113°, 39° - 101° and northwest of 39° - 101°, 42° - 92°, 47° - 87°.

Jan. 30, 23^h. 107 Tauri, Mag. 6.5. Northwest of 36° - 123°, 42° - 110°, 49° - 102°.

Jan. 31, 15^h. B.D. + 19°1110, Mag. 6.0. North of 37° - 124°, 41° - 96°, 38° - 76°.

Jan. 31, 16^h. χ^1 Orionis, Mag. 4.5. South of 47° - 124°, 47° - 96°, 41° - 69°.

Jan. 31, $16^h.5$. 57 Orionis, Mag. 5.8. North of 45° - 125°, 45° - 98°, 39° - 74°.

Jan. 31, $20^h.0$. 64 Orionis, Mag. 5.1. Throughout the U. S.

Jan. 31, 21^h. χ^2 Orionis, Mag. 4.7. Southwest of 40° - 124°, 34° - 108°, 28° - 95°.

Feb. 1, $0^h.5$. 71 Orionis, Mag. 5.1. Northwest of 38° - 124°, 49° - 110°.

(An occultation of Venus occurs Jan. 17, visible in South America between the parallels of 5° and 40° south latitude, between 0^h and 4^h Greenwich time.)

ARTHUR SNOW.
Assistant, Nautical Almanac Office, U. S. Naval Observatory.

VARIABLE STARS.

W Arietis.— This star is given in the B D Catalogue under the number 28° 518. It apparently disappeared and later was observed again and regarded as a Nova. In 1905 the Italian Astronomer Abetti observed a star in this region which doubtless is this same star. In September and October of this year it was observed as a very faint star by Hoffmeister and his observation is recorded in the Circular of Observations No. 11, issued October 12, 1919. It seems therefore that this star should not be regarded as a Nova, but rather as a variable of long and possibly irregular period.

Minima of Variable Stars of Short Period.

[Calculated by members of the Class in General Astronomy in Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1920 January							
	h m	° ′		d h	d	h	d	h	d	h	d	h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			10	3				
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	6	19;	14	12;	22	4;	29	20
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	7	23;	15	10;	22	19;	30	6
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	5	2;	12	14;	20	1;	27	12
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	6	11;	12	14;	24	19;	30	2
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	2	0;	9	3;	23	10;	30	13
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4	0;	10	21;	24	15;	31	11
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	3	16;	10	20;	18	0;	25	4
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	3	10;	12	5;	20	23;	29	18
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	1	2;	9	1;	16	23;	24	22
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	2	0						
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	3	10;	9	4;	20	15;	26	9
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	3	2;	9	21;	23	12;	30	7
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	5	1;	12	23;	20	20;	28	18
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	2	10;	10	17;	19	1;	27	9
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	7	20;	15	18;	23	15;	31	13
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	3	22;	17	3;	30	8		
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	1	21;	11	8;	20	19;	30	5
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	8	1			20	11		
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	7	2;	13	18;	20	10;	27	2
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	4	10;	12	14;	20	19;	28	23
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	3	12;	9	13;	21	14;	27	14
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	8	9;	17	1;	25	17		
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9			10	5;	20	15;	31	1
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	8	21;	16	21;	24	22		
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	4	17;	10	10;	21	21;	27	15
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	2	5;	7	20;	19	0;	24	15
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	1	13;	9	18;	17	23;	26	4
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	7	11;	15	2;	22	17;	30	8
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	4	9;	16	14;	28	19		
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	1	15;	8	19;	15	23;	23	3
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	4	6;	11	2;	24	17;	31	12
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	6	18;	16	1;	25	9		
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	5	2;	11	16;	24	22;	31	12
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	2	10;	10	20;	19	5;	27	15
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	2	12;	8	22;	21	19;	28	5
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	5	23;	13	5;	20	12;	27	18
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	4	22;	13	1;	21	3;	29	6
S Cancri	38.2	+19 24	8.2—10	9 11.6	6	11;	16	23;	26	10		
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	7	15;	14	12;	21	8;	28	4
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	1	9;	7	8;	19	5;	31	1
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	6	9;	13	3;	19	20;	26	14
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	6	7;	14	17;	22	3;	29	13
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	2	14;	9	4;	22	9;	28	23
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	5	19;	14	14;	23	10		
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	12	9;	19	7;	27	1		
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	1	3;	6	22;	21	12;	28	7
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	8	11;	15	23;	23	11;	30	23
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	7	12;	17	2;	27	16		
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	2	23;	10	10;	17	20;	25	7
133926 Hydrae	13 39.0	−26 23	8.6—12.7	2 21.5	1	8;	7	3;	18	17;	30	7
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	4	17;	11	16;	18	15;	25	15

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1920 January
	h m	° ′		d h	d h d h d h d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	2 18; 9 16; 23 11; 30 9
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.3	9 6; 17 16; 26 2
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	1 9; 9 1; 16 17; 24 9
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	7 12; 14 20; 22 4; 29 12
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	7 23; 16 6; 24 12
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	2 17; 9 14; 20 10; 29 6
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	11 23; 19 16;
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	1 2; 7 21; 21 12; 28 7
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	6 19; 15 4; 23 13; 31 23
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	6 13; 12 17; 25 0; 31 4
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	2 22; 9 2; 21 11; 27 15
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	6 19; 14 4; 21 13; 28 21
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	8 2; 16 6; 24 10
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	7 22; 15 12; 23 1; 30 14
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	1 4; 8 21; 16 15; 24 9
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	5 14; 13 14; 21 13; 29 13
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	8 17; 17 5
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	5 3; 14 11; 23 19
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	8 20; 18 4; 29 12
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	1 18; 9 0; 23 12; 30 18
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	7 14; 12 12; 21 10; 28 8
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	8 22; 24 3
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	7 12; 14 16; 21 20; 28 23
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	4 6; 11 9; 18 12; 25 14
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	2 13; 10 20; 19 4; 27 11
RR Draconis	40.8	+62 34	9.3—13	2 19.9	2 11; 9 23; 19 10; 27 22
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	2 23; 9 14; 22 21; 29 13
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	4 10; 17 8; 30 6
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	6 18; 14 9; 22 0; 29 16
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	6 0; 13 14; 21 4; 28 18
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	6 18; 13 23; 21 4; 28 8
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	1 12; 10 11; 19 10; 28 9
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	5 19; 12 13; 19 7; 26 2
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	6 5; 13 13; 20 22; 28 7
TT Lyrae	24.3	+41 30	9.4—11.6	5 05.8	4 17; 9 23; 20 11; 30 22
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	1 5; 7 18; 20 19; 27 8
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	2 22; 8 22; 20 23; 26 23
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	2 3; 8 19; 22 1; 28 16
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	3 19; 12 23; 22 2
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	1 17; 10 4; 18 14; 27 0
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	6 4; 12 23; 17 18; 26 12
UW Cygni	19.6	+42 55	10.5—13	3 10.8	2 14; 9 11; 23 6; 30 4
V Vulpec.	32.3	+26 15	8.2— 9.8	37 19.0	20 10
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	8 10; 17 1; 26 16
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	3 9; 12 14; 21 18; 30 23
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	8 8; 15 20; 23 8; 30 19
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	1 8; 8 23; 16 13; 24 3
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	3 17; 13 19; 21 23
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	5 12; 12 21; 20 6; 27 15
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	9 16; 19 9; 29 2
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	5 3; 13 0; 20 20; 28 17
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	2 0; 12 4; 22 17
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	24 21
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	4 7; 11 11; 19 20; 30 5
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.4	1 10; 9 17; 18 0; 26 7
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.3	4 9; 11 22; 19 10; 26 23
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	6 20; 15 2; 20 8; 31 13

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1920. January							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7			12 20					
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	7 12;	15 15;	23 18;	31 22				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	7 13;	15 7;	23 1;	30 19				
RW Cassiop.	130.7	+57 15	8.9—11.0	14 19.2	7 1		22 3;					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	6 8;	14 6;	22 5;	30 4				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	3 10;	11 5;	19 0;	26 19				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	6 4;	13 11;	20 18;	28 1				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		13		29				
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	8 22;	17 12;	26 2					
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	2 22;	14 1;	25 4					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0		14 6;	25 21					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	1 18;	9 10;	17 2;	24 17				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3		10 5;	20 8;	30 12				
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	4 6;	11 23;	19 16;	27 10				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	3 16;	9 5;	14 17;	20 6				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	6 7;	13 21;	19 10;	28 23				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	5 9							
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	1 15;	9 2;	16 13;	24 1				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	4 11;	11 14;	18 17;	26 1				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	6 4;	14 2;	22 1;	29 22				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 16;	13 19;	23 23					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		17 6						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	5 16;	13 15;	21 14;	29 12				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	7 3;	13 20;	20 13;	27 5				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3		10 4;	19 10;	28 17				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	5 19;	14 13;	23 6					
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0								
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	5 15;	12 10;	19 5;	26 0				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	1 14;	8 5;	21 10;	28 0				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	5 21;	15 13;	25 4					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	5 10;	13 10;	21 9;	29 9				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	2 20;	8 18;	22 5;	28 23				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	1 22;	7 18;	19 10;	25 5				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	5 2;	14 11;	23 20;	28 13				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	4 6		21 12					
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	7 15;	15 20;	24 0					
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	2 17;	9 17;	23 18;	30 19				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	6 23;	15 4;	23 9;	31 14				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	2 23;	8 11;	19 11;	30 11				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	1 1;	8 23;	24 1;	31 14				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	4 13;	11 23;	19 8;	26 18				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	5 0;	11 19;	18 13;	25 8				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	2 14;	8 22;	21 13;	27 21				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1		10 2;	19 20;	29 14				
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	8 18;	17 15;	26 11					
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	7 0;	13 1;	25 4;	30 6				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	2 3;	9 3;	23 4;	30 4				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		15 11						
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	5 14;	13 5;	20 19;	28 9				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	4 3;	9 21;	21 10;	27 5				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	3 7;	10 0;	23 12;	30 6				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	4 21;	15 5;	25 14					
Y Lyrae	34 2	+43 52	11.3—12.3	0 12.1	5 11;	11 11;	23 13;	29 14				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	3 18;	9 21;	22 3;	28 7				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1920. January					
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	2 15;	8 14;	20 12;	26 10		
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	5 21;	14 23;	24 2			
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6		11 17;	18 18;	25 18		
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	6 21;	13 21;	20 21;	27 21		
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	7 23;	15 21;	23 21			
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	8 11;	16 3;	23 20			
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	2 13;	9 17;	16 21;	24 2		
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	2 19;	11 4;	19 13;	27 22		
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	5 17;	12 1;	24 16;	30 23		
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	8 7		24 16			
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	2 5;	11 2;	19 28;	28 20		
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	2 3;	8 20;	22 7;	29 1		
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	5 3;	11 20;	18 14;	25 7		
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	5 13		20 7			
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	4 6;	12 3;	20 0;	27 20		
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	1 3;	8 1;	14 22;	28 17		
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	5 1;	14 18;	24 12;	29 9		
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	6 11;	15 2;	23 18			
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	3 8;	8 17;	19 10;	30 4		
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	2 23;	13 20;	24 17			
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	6 10;	12 20;	19 6;	23 16		
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	3 20;	13 19;	23 19;	28 18		
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.7	1 19;	12 16;	23 13;	29 0		
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	5 20;	11 7;	22 14;	27 15		
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1 0;	8 7;	20 21;	27 4		
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	9 16;		21 9			
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.9	3 3;	10 2;	24 1;	31 1		

UV Persei.—Recent observations of this variable show that one interval between successive maxima was 214 days, while another was 299 days. It seems therefore that this star, as is the case with other stars of the same type of variables, is of irregular period.

U Cygni, 201646.—Miss Cannon finds strong bright hydrogen lines in the spectrum of the long period variable U Cygni, 201647, photographed on October 22, 1919. The spectrum of this star is of class N in which ordinarily such lines are absent.

Harvard College Observatory Bulletin 701.
Cambridge, Mass., Nov. 17, 1919.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, October, 1919.

All those members and friends of the A.A.V.S.O. who were present at the Annual Meeting on November 8th at Harvard Observatory agree that the occasion was very enjoyable. The prosperity of the Association was apparent from the large attendance, forty-six sitting down together at one table at dinner. The enthusiasm on every hand, and the definite plans made for further progress augur well for our future as we commence our second hundred-thousand observations.

Variable Star Observations, October, 1919.

Sept. 0 = 2422202 Oct. 0 = 2422232 Nov. 0 = 2422263

001046
X Androm.

J.D. 242	Est.	Obs.
2260.7	< 13.0	E

001032
S Sculptoris

2232.7	10.5	δ

001620
T Ceti

2208.6	5.8	L
24.3	6.3	

001755
T Cassiop.

2206.4	9.5	Pe
20.3	8.6	
22.3	8.2	L
38.5	8.0	K
38.5	8.2	B
38.6	8.3	M

001726
T Androm.

2204.4	9.4	Pe
20.3	9.9	
54.5	11.7	K
54.5	11.7	Cl
54.5	11.4	B
60.7	11.8	Pi
61.6	11.9	Do

001838
R Androm.

2204.4	10.2	Pe
06.4	9.7	
20.3	8.8	
26.4	8.5	
49.6	7.5	Pt
50.5	7.9	Jk
50.6	7.7	Do
51.6	7.5	V
52.5	7.6	Cl
60.6	7.	Hu

001909
S Ceti

2204.4	< 12.5	Pe

002438a
T Sculptoris

2232.7	11.5	δ

002438b
RR Sculptoris

2232.7	< 13.2	δ

002546
T Phoenicis

2232.7	10.6	δ

003179
Y Cephei

J.D. 242	Est.	Obs.
2261.6	12.3	Hu

004047
U Cassiop.

2226.4	11.4	Pe
38.5	11.2	K
38.5	11.2	B
60.7	12.6	E

004958
W Cassiop.

2238.5	8.9	K
38.5	8.8	B
61.6	8.5	Hu

010940
U Androm.

2239.5	11.3	K
39.5	11.2	Cl
49.6	11.6	B
60.7	11.7	E

011040
UZ Androm.

2261.5	10.5	B

011208
S Piscium.

2260.6	< 14.2	B

011712
U Piscium

2260.7	10.9	E

012350
RZ Persei

2238.6	12.9	B
60.7	13.2	E

012502
R Piscium

2204.4	9.5	Pe
24.4	10.7	
26.4	10.3	
60.7	11.6	E

013238
RU Androm.

2261.6	12.5	B

014958
X Cassiop.

2234.9	11.5	M
40.6	8.7	Cl
40.6	10.2	B

015354
U Persei.

J.D. 242	Est.	Obs.
2240.6	9.4	Cl
40.6	9.1	B
61.6	9.2	

021024
R Arietis

2220.4	9.0	Pe
24.3	8.7	L
38.6	8.2	K
38.6	8.2	B
49.6	8.3	Pt
60.7	8.0	Pi

021143a
W Androm.

2261.6	11.1	B

021403
o Ceti

2203.4	3.6	Pe
06.9	3.6	Pe_2
22.8	4.6	
24.6	4.0	L
28.4	4.8	Pe_3
32.3	4.8	Bh_2
49.7	5.8	Pt
50.7	5.9	Su
58.7	6.0	Mu

021558
S Persei

2245.6	8.7	B

022000
R Ceti

2226.9	8.4	Pe_2

022150
RR Persei

2249.6	12.9	B
60.7	12.6	E

023080
RR Cephei

2228.3	< 12.5	L

023133
R Trianguli

2245.6	7.0	B
60.7	6.0	Pi

024356
W Persei

2226.3	10.0	Pe
44.6	9.4	Pt
45.5	9.3	Cl
45.6	9.2	B
56.5	9.1	Cl
60.6	9.2	Hu
60.6	9.3	Hn

025050
R Horolog.

J.D. 242	Est.	Obs.
2232.8	12.5	δ

025751
T Horolog.

2232.8	11.5	δ

025938
ρ Persei

2261.5	4.2	Ms
61.5	4.0	

030514
U Arietis

2234.6	< 13.1	Y

032043
Y Persei

2226.3	9.4	Pe
40.6	8.6	B
49.6	9.6	Pt
60.6	8.5	Hu
61.6	8.2	B

032335
R Persei

2254.7	8.3	Pt
61.6	8.3	B

034625
U Eridani

2196.8	12.9	δ
2232.8	11.9	

035124
T Eridani

2196.8	8.7	δ
2232.8	10.8	

040725
W Eridani

2196.8	< 12.9	δ
2232.8	12.8	

041619
T Tauri

2257.8	9.6	M

042215
W Tauri

2227.4	9.1	Pe
57.8	9.8	M
60.7	10.0	Pi

043065
T Camelop.

2222.3	10.8	L

043274
X Camelop.

J.D. 242	Est.	Obs.
2250.6	8.4	Cl
50.6	8.5	B
50.6	8.5	K

043263
R Reticuli

2232.8	7.6	δ

043738
R Caeli

2196.8	11.8	δ
2232.8	11.4	

044349
R Pict.

2196.8	7.7	δ

044617
V Tauri

2260.7	12.4	Pi

045307
R Orionis

2234.8	11.4	M

045514
R Leporis

2205.6	9.1	L
24.6	8.9	
60.9	8.9	Pt

050953
R Aurigae

2249.8	< 12.4	M

051247
T Pict.

2196.8	10.7	δ
2232.8	9.5	

051533
T Columbae

2196.7	11.9	δ
2232.8	11.9	

052036
W Aurigae

2250.6	< 13.0	B

052034
S Aurigae

2249.8	9.3	M
60.6	8.5	B
60.7	9.0	Pi

052404
S Orionis

2234.8	12.5	M

VARIABLE STAR OBSERVATIONS, October, 1919—Continued.

053005a
T Orionis

J.D.	Est.	Obs.
242		
2205.6	10.2	L
24.6	11.0	
34.8	9.9	M

053531
U Aurigae

2250.6	11.3	B

054319
SU Tauri

2208.6	9.8	L
24.6	9.8	
34.8	9.4	M
49.8	9.5	
60.6	9.5	B
60.7	9.4	Pi
61.7	9.4	E
65.7	9.5	
71.7	9.4	
71.7	9.4	M
71.7	9.5	Pi
71.7	9.5	Yo

054615a
Z Tauri

2260.7	<12.5	Pi

054615c
RU Tauri

2260.7	12.5	Pi

054629
R Columbae

2196.8	13.2	δ
2232.8	<13.2	

054974
V Camel.

2234.8	<12.8	M

054920
U Orionis

2234.8	9.0	M
49.8	9.1	
60.7	9.5	Pi
60.9	9.5	Pt

055686
R Octantis

2232.7	10.7	δ

060450
X Aurigae

2260.6	11.6	B
60.7	11.7	Pi

060547
SS Aurigae

2205.6	<12.4	L
08.6	<13.0	
19.4	<11.6	
20.4	<11.6	

SS Aurigae

J.D.	Est.	Obs.
242		
2222.3	<12.4	L
24.6	<13.0	
28.6	11.0	
34.8	<12.4	M
49.8	<12.4	
50.7	<12.4	E
57.8	<12.4	M
60.6	<13.9	B
60.7	<13.0	Pi
60.7	<13.3	E
61.7	<13.3	
65.7	<13.3	
71.7	<12.4	Pi

063159
U Lyncis

2249.6	<13.1	Y

064932
Nova Gemin. 2

2228.6	13.2	L

065111
Y Monoc.

2234.8	9.6	M

065208
X Monoc.

2208.6	6.9	L
28.6	7.3	

070122a
R Gemin.

2234.8	7.0	M
60.9	6.9	Pt

070122b
Z Gemin.

2234.8	12.3	M

070122c
TW Gemin.

2234.8	8.4	M

070109
V Can. Min.

2234.8	8.4	M

070310
R Can. Min.

2208.6	10.9	L
28.6	11.0	

071044
L^2 Puppis

2196.8	6.0	δ
2232.8	4.9	δ_2
56.9	4.5	Bh

072708
S Can. Min.

242		
2234.9	7.9	M
60.9	9.0	Pt

072811
T Can. Min.

2234.8	<12.5	M

073508
U Can. Min.

2234.9	10.2	M

073723
S Gemin.

2234.9	10.0	M

074323
T Gemin.

2234.9	9.1	M

074922
U Gemin.

2208.6	<12.4	L
24.6	<12.6	
28.6	<12.4	
34.9	<12.4	M
60.7	<12.4	Pi
60.7	<13.3	E
61.7	<13.7	
65.7	<13.7	

081617
V Cancri

2260.9	7.6	Pt

085008
T Hydrae

2260.9	8.6	Pt

085120
T Cancri

2228.6	9.1	L

090425
W Cancri

2228.6	7.9	L

091868
RW Carinae

2232.8	<12.8	δ

092962
R Carinae

2195.5	6.0	δ
96.8	6.7	
2232.8	4.7	δ_2

093178
Y Draconis

2249.6	<13.	Y

094211
R Leonis

2234.9	10.5	M

094262
l Carinae

J.D.	Est.	Obs.
242		
2233.8	3.9	δ

100661
S Carinae

2170.6	6.7	Tp
95.5	6.0	δ
96.8	6.2	
2232.8	5.8	δ_2

103769
R Urs. Maj.

2245.5	10.3	Cl

114441
X Centauri

2170.6	8.3	Tp

123160
T Urs. Maj.

2226.3	12.2	Pe
49.5	9.4	B

123459
RS Urs. Maj.

2226.3	11.9	Pe
49.5	12.6	B

123961
S Urs. Maj.

2219.3	8.0	L
27.3	8.0	Pe_2
34.9	8.3	M
35.5	7.5	Pi
38.5	7.7	Cl
44.6	8.6	Pt
49.5	7.8	B

131283
U Octantis

2171.7	9.7	Tp
2218.6	8.5	
32.7	8.6	δ

133273
T Urs. Min.

2249.5	12.7	B

133633
T Centauri

2168.1	6.4	Tp_2
2218.5	6.9	Tp

134236
RT Centauri

2170.7	9.3	Tp
2218.5	9.3	

134440
R Can. Ven.

2240.5	8.8	B

140528
RU Hydrae

J.D.	Est.	Obs.
242		
2170.7	11.7	Tp
2218.5	9.0	

140959
R Centauri

2168.1	8.2	Tp_2
92.6	8.9	δ
2218.5	9.5	Tp

141567
U Urs. Min.

2235.5	9.3	Pi
40.5	9.2	Cl
40.5	9.1	B

141954
S Bootis

2220.8	9.7	L_2
24.3	9.9	Pe

142584
R Camelop.

2240.5	<12.2	Cl
40.5	<12.3	B

142539
V Bootis

2221.8	10.2	L_2
40.5	10.1	Cl
40.5	10.2	B

145254
Y Lupi

2170.7	<13.9	Tp
92.6	14.0	δ
2218.5	10.2	Tp

151731
S Cor. Bor.

2249.5	12.7	B
50.5	13.4	Y

151714
S Serpentis

2216.3	9.1	L
27.3	9.7	

152849
R Normae

2168.1	12.6	Tp
92.6	13.3	δ
2218.5	11.7	Tp

153378
S Urs. Min.

2235.5	9.2	Pi
51.5	8.7	V

VARIABLE STAR OBSERVATIONS, October, 1919—Continued.

154428
R Cor. Bor.

J.D.	Est.	Obs.
242		
2208.3	6.1	L
10.3	6.1	
15.3	6.2	
19.3	6.4	
20.3	6.4	
22.3	6.6	
24.3	6.6	
24.3	6.7	Pe
26.3	6.7	
27.3	6.4	L
28.3	6.3	
32.3	6.0	
35.5	6.0	Pi
38.5	6.7	Cl
38.6	6.2	M
43.7	6.4	Mu
44.6	6.5	Pt
45.7	6.1	Mu
49.5	6.2	Bn
49.6	6.1	Mu
49.6	6.4	Pt
53.6	6.0	Mu
53.6	6.3	Pt
54.6	6.4	
58.6	6.0	Mu

154536
X Cor. Bor.

2251.5	9.7	V
52.5	9.7	B

154639
V Cor. Bor.

2238.6	9.0	M

154615
R Serpentis

2249.5	13.0	B

154736
R Lupi

2192.6	10.4	δ
2218.6	10.0	Tp

155229
Z Cor. Bor.

2245.5	12.5	B

155947
X Herculis

2203.3	6.3	Pe
27.4	6.9	
43.7	6.5	Mu
45.7	6.7	
49.6	6.5	
50.6	6.6	Su
53.6	6.5	Mu
58.6	6.5	

161138
W Cor. Bor.

J.D	Est.	Obs
242		
2250.6	9.8	Do
50.6	9.8	Jk

161607
W Ophiuchi

2222.3	12.0	L

162119
U Herculis

2203.3	11.1	Pe
26.8	10.4	Pe_2
47.6	7.1	Bh
49.6	8.0	Pt
51.5	8.0	V
55.6	7.0	Bh

162542
g Herculis

2203.3	5.5	Pe
34.6	6.0	Su
35.6	6.0	
43.7	5.4	Mu
45.7	5.3	
49.7	5.4	
52.6	6.0	Su
53.7	5.4	Mu
58.6	5.2	

163137
W Herculis

2250.5	12.8	Y

163266
R Draconis

2203.3	8.5	Pe
50.5	11.0	Y

164055
S Draconis

2239.6	8.9	M
53.6	9.3	Pt

164715
S Herculis

2203.4	8.6	Pe
06.4	8.6	
50.5	10.2	K
50.5	10.1	Cl
50.5	9.6	B

164844
RS Scorpii

2171.2	11.8	Tp
92.6	12.2	δ

165030
RR Scorpii

2170.7	9.9	Tp
92.6	8 3	δ
96.7	7.9	
2218.5	6.7	Tp

165631
RV Herculis

J.D.	Est.	Obs.
242		
2203.4	12.0	Pe
24.3	12.3	
28.3<12.7		
38.6	12.5	M

170627
RT Herculis

2245.6	12.0	B

171401
Z Ophiuchi

2245.5	11.7	B

172486
S Octantis

2171.2	12.0	Tp_2
2218.6<13.2		Tp
32.7<13.2		δ

172809
RU Ophiuchi

2250.5	10.4	K
50.5	11.1	Cl
50.5	10.5	B

173557
TY Draconis

2228.4	9.4	Pe

175111
RT Ophiuchi

2238.5	11.5	K
38.5	11.4	B

175458a
T Draconis

2250.5<12.5		Y

175458b
UY Draconis

2252.5	11.2	B

175519
RY Herculis

2203.4	9.3	Pe
26.4	11.1	
45.6	11.8	Do

180363
R Pavonis

2171.2	11.4	Tp_2
92.6	9.5	δ
96.7	9.2	
2218.6	8.0	Tp
32.7	8.2	δ

180565
W Draconis

2238.6	11.9	B
60.6	12.8	

180531
T Herculis

J.D.	Est.	Obs.
242		
2203.4	8.0	L_2
03.4	8.4	Pe
19.3	8.4	L
27.3	8.4	
27.4	8.4	Pe
38.6	8.7	M
44.6	9.1	Pt
51.6	9.3	V
51.6	10.0	Hu

181031
TV Herculis

2203.4	12.6	L
19.3<12.6		

181136
W Lyrae

2204.3	11.0	Pe
19.4	10.0	L
27.3	10.0	Pe
28.3	10.0	L
50.5	10.8	Y
53.6	8.1	Pt
54.6	8.3	Hu
54.6	8.5	Pi
60.5	7.9	B
60.6	8.1	Ya

181103
RY Ophiuchi

2240.5<11.3		Pi

182133
RV Sagittarii

2170.6	12.7	Tp_3
92.6	12.0	δ
96.7	12.1	
2218.6	11.7	Tp

182224
SV Herculis

2219.3	11.6	L
27.8	10.9	Pe_2
45.6	9.3	Do

183225
RZ Herculis

2250.5	12.2	Y

183308
X Ophiuchi

2220.8	8.0	L_2
40.5	8.7	Pi
40.6	8.7	B

184134
RY Lyrae

2251.6	10.2	Hu

184205
R Scuti

J.D.	Est.	Obs.
242		
2208.3	5.4	L
10.3	5.4	
20.3	5.8	Pe
22.3	5.4	L
24.3	5.8	
24.4	5.8	Pe
27.3	6.1	L
28.4	6.0	Pe
32.3	6.0	L
34.6	5.9	Pt
38.6	6.5	
38.6	5.8	M
39.6	6.3	Pt
40.5	6.3	Pi
43.7	6.0	Mu
44.6	6.9	Pt
45.7	6.0	Mu
49.5	5.2	Ms
49.6	6.2	Pt
49.6	5.9	Mu
50.5	5.9	Pi
50.6	6.1	Su
51.6	6.0	Bh
52.5	5.2	Ms
52.5	5.5	
52.6	6.1	Su
53.6	5.9	Mu
53.6	6.0	Pt
54.6	5.8	
54.6	5.6	Ya
54.6	5.9	Hu
55.6	6.0	Bh
56.5	5.2	Ms
57.5	5.9	
58.6	5.9	Mu
58.6	5.8	Bh
60.5	5.9	Ms
60.5	5.0	Bn
60.5	6.1	Ms
60.6	5.7	Pt
61.5	6.1	Ms

184300
Nova Aquilae 3

2219.3	7.4	L
20.3	7.5	Pe
24.4	7.4	
26.4	7.8	
27.3	7.4	L
34.6	7.2	Pt
38.5	7.8	Cl
38.6	7.7	M
38.6	7.4	Pt
39.6	7.1	
44.6	7.4	
47.6	7.2	Bh
49.6	7.3	Pt
51.5	7.6	V
53.6	7.2	Pt

VARIABLE STAR OBSERVATIONS, October, 1919—Continued.

Nova Aquilae 3

J.D.	Est.	Obs
242		
2254.6	7.5	Pt
58.6	7.1	Bh
60.6	7.5	Pt
60.6	7.0	Ya

184748 TU Draconis

2227.4	< 12.5	Pe

185243 R Lyrae

2228.3	4.4	Pe
31.6	4.3	Bh
34.5	4.3	
35.6	4.3	
43.7	4.2	Mu
43.7	4.2	Bh
45.6	4.2	Mu
49.6	4.2	
49.6	4.1	Bh
53.6	4.2	Mu
55.6	4.1	Bh
56.6	4.1	
58.6	4.3	Mu
58.6	4.2	Bh

190108 R Aquilae

2245.6	9.4	B

190529 V Lyrae

2229.6	< 12.	Y

190967 U Draconis

2254.6	11.9	Hu

190926 X Lyrae

2240.5	9.0	Pi

190925 S Lyrae

2228.3	< 13.1	L
61.6	12.6	Do

***191019* R Sagittarii**

2224.3	10.7	Pe
28.3	10.7	
38.5	11.7	K
38.5	10.8	B

***191033* RY Sagittarii**

2165.6	6.6	Tp
69.7	6.7	
70.7	6.7	
71.7	6.8	

RY Sagittarii

J.D.	Est.	Obs.
242		
2192.7	7.0	δ
96.7	6.9	
2213.3	6.5	L
18.6	6.7	Tp
20.3	6.6	L
22.3	6.3	
27.3	6.7	
32.7	7.0	δ

***191124* TY Sagittarii**

2169.0	10.0	Tp_3
92.6	10.9	δ
96.7	11.1	
2218.6	12.2	Tp
32.7	12.2	δ

***191133* —Sagittarii**

2169.4	9.9	Tp_4
2218.6	9.0	Tp

191350 TZ Cygni

2249.6	10.8	Y

193311 RT Aquilae

2245.6	12.0	B

193449 R Cygni

2254.6	< 12.1	Pi

193732 TT Cygni

2240.5	8.0	Pi
54.6	7.2	Hu

***193972* T Pavonis**

2170.7	11.5	Tp_3
92.6	13.2	δ
96.7	13.0	
2218.6	< 13.2	Tp
32.7	13.5	δ

194048 RT Cygni

2254.6	11.9	Hu

194348 TU Cygni

2252.6	13.0	B

194632 χ Cygni

J.D.	Est.	Obs.
242		
2227.4	11.5	Pe_2
38.6	11.7	K
38.6	11.8	B
50.5	12.2	
50.5	12.3	Cl
50.5	12.1	K
51.6	< 11.9	M
54.6	12.4	Do
54.6	< 12.5	Hu
60.6	12.3	B

***194659* S Pavonis**

2169.4	8.1	Tp_4
92.6	7.8	δ_2
96.7	7.6	
2218.6	6.9	Tp
32.7	7.4	δ_2

***194929* RR Sagittarii**

2170.7	10.3	Tp_3
94.8	11.4	δ
96.7	12.2	
2218.6	12.5	Tp
32.7	13.0	δ

195116 S Sagittae

2243.7	5.3	Mu
45.7	5.4	
49.6	5.9	
53.6	5.3	
54.6	5.5	Bn
58.6	6.1	Mu
60.6	5.5	Bn

***195202* RR Aquilae**

2245.6	12.9	B

195849 Z Cygni

2235.5	11.5	Pi
50.6	11.6	B
51.6	< 11.6	V
54.5	< 12.1	Pi

200212 SY Aquilae

2227.3	< 12.3	L

200357 S Cygni

2254.5	< 11.7	Pi

200647 SV Cygni

2235.5	9.3	Pi
51.6	9.0	M
54.6	8.5	Hn

200715a S Aquilae

J.D.	Est.	Obs.
242		
2238.6	11.0	M
38.6	11.2	K
38.6	11.1	B
60.6	11.5	Ya

200715b RW Aquilae

2238.6	9.0	B
38.6	9.2	M
38.6	8.9	K
40.5	9.2	Pi
58.6	9.2	Ya_2

***200822* W Capricorni**

2250.6	12.4	Y

200938 RS Cygni

2220.4	7.1	L
40.6	8.0	Pi
51.6	8.4	M
54.7	8.5	Pt
60.6	7.5	Ya

200916 R Sagittae

2238.6	9.1	M
58.6	8.8	Ya_2

***200906* Z Aquilae**

2252.5	8.9	B

201008 R Delphini

2216.3	12.2	L
27.3	12.3	
60.5	13.2	B

201130 SX Cygni

2250.5	11.6	Y
60.6	9.5	B

***201121* RT Capricorni**

2216.3	7.2	L
54.6	8.4	Pt

***201139* RT Sagittarii**

2171.2	8.6	Tp_2
94.8	7.8	δ_2
2216.6	7.6	Tp
32.7	8.3	δ

201647 U Cygni

2238.1	7.1	Pi_2
51.6	6.8	M
54.6	7.1	Pt

***202240* U Microscopii**

J.D.	Est.	Obs.
242		
2194.8	11.4	δ
2232.7	12.4	

202539 RW Cygni

2240.6	9.0	Pi
50.5	9.1	Gd
51.6	9.3	M

202817 Z Delphini

2240.6	9.4	Pi
60.6	9.4	

202954 ST Cygni

2250.5	13.0	Y
50.6	13.0	B

202946 SZ Cygni

2240.7	9.5	Pi
54.6	9.6	Hu

203226 V Vulpeculae

2234.8	9.8	M
40.7	8.9	Pi
54.7	8.8	Pt
60.6	8.8	Pi

203611 Y Delphini

2249.6	13.6	B

203847 V Cygni

2234.8	13.0	M
60.6	13.2	B

203816 S Delphini

2245.6	8.8	B
51.6	9.4	V
60.6	8.9	Hu

***203905* Y Aquarii**

2227.4	13.0	Pe

***204215* U Capric.**

2250.5	12.9	Y

***204405* T Aquarii**

2227.4	10.8	Pe
40.5	12.0	B
60.6	12.8	

204846 RZ Cygni

2234.8	< 13.1	M

VARIABLE STAR OBSERVATIONS, October, 1919—Continued

205017
X Delphini

J.D.	Est.	Obs.
242		
2260.5	13.2	B

205627
RR Capric.

2170.7	8.3	Tp_3
94.8	9.6	δ
2232.7	11.5	

205923
R Vulpeculae

2234.8	9.5	M
60.6	10.9	Hu
60.6	11.6	Pi

210129
TW Cygni

2250.5	<13.	Y

210116
RS Capric.

2254.6	8.5	Pt

210868
T Cephei

2210.3	10.6	L
22.3	10.5	
34.8	9.5	M

211614
X Pegasi

2250.5	<13.5	Y

212030
S Micros.

2170.7	<13.4	Tp
94.8	11.4	δ
2232.7	13.4	

213244
W Cygni

2208.3	5.8	L
10.3	5.9	
15.3	5.9	
20.3	5.7	
22.3	5.8	
27.3	5.9	

213678
S Cephei

J.D.	Est.	Obs.
242		
2260.6	9.4	Hu

213753
RU Cygni

2234.8	9.0	M
40.7	8.5	Pi

213843
SS Cygni

2203.4	10.9	L
05.6	8.1	
08.3	8.1	
10.3	8.2	
13.3	8.3	
15.3	8.4	
16.3	8.5	
19.3	10.0	
20.3	10.1	
22.3	10.3	
24.3	11.0	
27.3	11.2	
28.3	11.3	
32.3	11.4	
34.8	11.5	M
38.5	11.7	Cl
38.5	11.8	K_2
38.5	11.7	B
39.5	11.9	Cl
40.5	11.7	
40.5	11.9	B
45.5	11.7	
45.5	11.0	Cl
47.5	12.0	
49.5	11.6	E
49.5	11.8	B
49.8	12.1	M
50.5	11.8	B
50.5	12.0	Y
50.5	11.9	Cl
50.5	11.5	K
50.5	11.8	Do
50.5	11.8	Pi
51.5	<11.3	
51.6	<11.3	V
52.5	12.0	Cl
52.6	11.5	B
54.5	11.4	Cl

SS Cygni

J.D.	Est.	Obs.
242		
2254.5	11.5	K
54.5	11.7	B
54.5	11.5	E
54.5	11.8	Pi
54.6	11.8	Do
56.5	11.9	Cl
56.5	11.6	B
56.5	<11.3	Pi
56.6	11.7	Do
56.6	11.7	Jk
57.8	12.0	M
60.5	11.7	Pi
60.6	11.4	B
60.6	11.7	Hu
60.6	11.5	Y
61.5	11.9	Cl
61.6	11.6	Do
61.6	11.6	Jk
61.6	11.4	B
65.5	8.4	E
71.5	10.2	
71.5	10.4	Sh
71.5	9.9	Gd
71.5	10.2	J
71.5	10.2	S
71.5	10.3	Jk
71.5	9.9	Ya
71.5	10.2	Pi
71.5	10.1	Bu
71.5	10.1	M
71.5	10.2	Wh

213937
RV Cygni

2234.8	8.0	M
54.7	7.8	Pt
56.5	8.1	Pi
60.6	7.2	Hu

214247
R Gruis

2170.7	<13.7	Tp
94.8	<13.5	δ

215934
RT Pegasi

2260.7	<12.7	Pi

220412
T Pegasi

J.D.	Est.	Obs.
242		
2220.4	<12.7	L

221948
S Gruis

2170.7	7.7	Tp_3
94.8	8.5	δ
2232.7	10.2	

222439
S Lacertae

2215.3	7.9	L
28.3	8.4	
60.5	10.2	Pi

223462
T Tucanae

2170.7	9.4	Tp
94.8	10.8	δ
2232.7	13.1	

223841
R Lacertae

2228.3	<12.5	L

225120
S Aquarii

2250.5	8.7	Y

225914
RW Pegasi

2249.6	13.6	B

230110
R Pegasi

2250.6	12.0	Y

230759
V Cassiop.

2238.5	9.7	K
38.5	9.6	B
50.5	9.6	Hn
51.6	10.5	V
60.5	11.1	Pi

231425
W Pegasi

2219.4	11.2	L
34.8	11.7	M

231508
S Pegasi

J.D.	Est.	Obs
242		
2227.4	10.1	Pe_2

232746
V Phoenicis

2232.7	13.4	δ

232848
Z Androm.

2260.6	9.2	Pi

233335
ST Androm.

2256.5	10.5	Hn
56.6	10.9	Do
60.5	10.9	Pi
60.6	9.5	Hu

233815
R Aquarii

2254.7	8.1	Pt

235053
RR Cassiop.

2252.5	11.2	B
60.6	11.4	Pi

235150
R Phoenicis

2232.7	11.6	δ

235350
R Cassiop.

2247.6	9.1	B
60.6	10.5	Pi

235855
Y Cassiop.

2251.6	<11.0	V
60.6	10.0	Pi

235939
SV Androm.

2250.6	11.9	Y
60.6	11.6	Pt

No. of Observations: 819. No. of Stars Observed: 240. No. of Observers: 30.

The program of the meeting was rather restricted owing to the shortness of time, but a great deal of material was presented and discussed. In the absence of President Bancroft, Vice-President McAteer presided. Mr. Olcott presented the report of the committee appointed to prepare a Memorial of Prof. Pickering, and this fitting tribute will soon be in the hands of all the members. Mr. Pickering outlined the work of the chart committee in standardizing the chart equipment of the Association. Professor Bailey presented the report of the slide com-

mittee, and a little later showed selections from the 233 slides in the Association collection. This collection is available for all members who can make use of it, with no charge except postage, and those desiring to take advantage of this offer should communicate with Professor Bailey. The catalogue of this collection has been issued through the kindness of Mr. C. E. Barns. Mr. Campbell announced that the Association has now arranged for the loaning of a six-inch, the Association's five-inch, a four-inch and other telescopes, which means practically a net increase of equipment. The proposed Constitutional amendment authorizing the use of two-thirds of the Life-Membership Fund for the purchase of telescopes to be loaned to deserving members was adopted and this enables the Association to acquire additional equipment. Any members who know of good telescopes not in use are requested to notify Miss Annie J. Cannon, of Harvard Observatory, the chairman of the telescope committee—provided the owner cannot be persuaded to join the ranks of active observers.

The more social features of the meeting were equally important, and included an inspection of the Observatory, and, at the invitation of Dr. Stetson, of the Astronomical Laboratory. Miss Cannon entertained at a delightful afternoon tea, and the evening was closed by a banquet at the Hotel Thorndike. Rev. Joel H. Metcalf was the guest of honor, and told many of his experiences in the field in France.

The following officers were elected:

President, Mr. Leon Campbell; Vice-President, Prof. Anne S. Young; Councillors, D. B. Pickering and Chas. T. Whitehorn.

Mr. D. P. Pickering, in recognition of his munificence and unflagging zeal, was elected a Patron of the Association.

Dr. Harlow Shapley, of Mt. Wilson, was elected Honorary Member, in recognition of his valuable photometric researches.

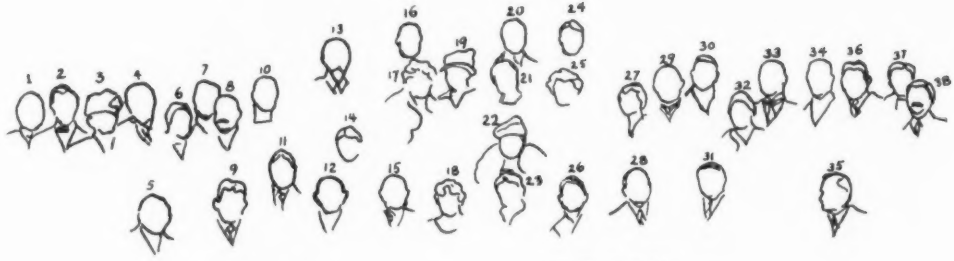
Mr. Chas. A. Brunn, Dr. Chas. C. Godfrey, and Mr. Leon Campbell were elected Life Members. The following were elected Active Members:

Leon Barritt, New York City.
Edwin T. Brewster, Andover, Mass.
Robert H. Brown, New York City.
Sterling Bunch, Springtown, Texas.
N. P. Case, South Weymouth, Mass.
Radha Govinda Chandra, Bagchar Jessore, India.
Miss Florence Cushman, Cambridge, Mass.
Thurston Hatcher, Atlanta, Ga.
J. W. L. Henckel, Yonkers, New York.
Miss Mabel A. Gill, Belmont, Mass.
William Henry, Brooklyn, N. Y.
Edward W. Clement, Hudson, N. H.
Theodore S. Kimball, Hudson, N. H.
Miss Louise F. Jenkins, Mt. Holyoke College, South Hadley, Mass.
Miss Eva F. Leland, Cambridge, Mass.
Miss Johanna C. S. Mackie, Winthrop, Mass.
Togota Kadono, Ozaba, Tokio, Japan.
Ronald B. Macdonald, West Somerville, Mass.
Mrs. J. B. Roberts, Los Angeles, Cal.
Dr. G. A. Shook, Wheaton College, Norton, Mass.
J. Arnold Wright, New Bedford, Mass.

PLATE LIII

THE ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS AT HARVARD COLLEGE OBSERVATORY, NOVEMBER 8, 1919.

Key to Plate.



1. E. S. King
2. G. A. Shook
3. Mrs. H. R. Schulmaier
4. C. C. Godfrey
5. F. H. Spinney
6. Miss A. C. Maury.
7. A. C. Perry
8. H. R. Schulmaier
9. A. B. Burbeck
10. Miss H. L. Leavitt
11. E. T. Brewster
12. D. B. Pickering
13. J. E. G. Yalden
14. Mrs. E. T. Brewster
15. C. Y. McAteer
16. S. I. Bailey
17. Miss A. J. Cannon
18. Miss M. D. Applegate
19. Miss H. Harwood
20. H. O. Eaton
21. Miss L. F. Jenkins
22. Miss Helen M. Swartz
23. Mrs. M. Morris
24. W. T. Olcott
25. Miss F. Cushman
26. Miss I. E. Woods
27. Miss M. A. Gill
28. T. C. H. Bouton
29. M. J. Jordan
30. C. A. Mowry
31. E. W. Clement
32. Miss M. A. Hawes
33. C. T. Whitehorn
34. Dr. Bell
35. J. A. Wright
36. R. B. Macdonald
37. L. D. Yont
38. Leon Campbell

This brings the active membership of the Association to a total of 160.

The undersigned was appointed by the Council as Recording Secretary to relieve the Secretary, Mr. Olcott, of the burden of preparing the monthly reports. Single copies of the observations should be sent either to him or to Mr. Campbell, at the Harvard Observatory. In order to allow time for proof-reading, observers are requested to mail their December and all subsequent reports in time to reach H.C.O. on or before the twentieth of the month. It may be well to point out that there are many possibilities of error between the observer's note book and the printed page, and for the sake of accuracy observers are requested to call attention to any discrepancies between the two.

The following observers contributed to this report: Bouton, Brown, Bunch, Burbeck, Clement, Dawson, Miss Downer, Eaton, Godfrey, Henckel, Hunter, Miss Jenkins, Jordan, Kimball, Lacchini, McAteer, Mrs. Morris, Mundt, Peltier, de Perrot, Pickering, Shook, Suter, Miss Swartz, Tapia, Vrooman, Whitehorn, Yalden, Yont, and Miss Young.

HOWARD O. EATON,
Recording Secretary.

COMET AND ASTEROID NOTES.

Two Periodic Comets Rediscovered.—A cablegram from Kyoto, Japan, to Harvard College Observatory announced the discovery of a comet by Sasaki of the Kyoto Observatory. On October 25 the comet was about seven degrees west of the star ψ Capricorni. Since then it has moved rather rapidly northeastward, passing through Aquarius and Pisces. This course if continued will carry it through Aries into Taurus north of the Pleiades by the end of December.

Preliminary computation of the elements indicates that this comet is Finlay's periodic comet, which was expected to return this year. The period appears to have been lengthened more than a month since 1900. The comet is 5′ in diameter, diffuse and seen at present as easily with a small telescope as with a large one.

In the same announcement telegram from Harvard is given an observation by Fayet on October 29 of a comet which is probably Schaumasse's periodic comet 1911 VII, for which elements and an ephemeris were given in the October number of POPULAR ASTRONOMY, p. 550. The observed place of the comet was

Oct. 29.6554 α $12^h\ 03^m\ 00^s.9$ δ $+8°\ 24'\ 30''$

and its magnitude was estimated at 12. The comet is apparently in advance of its predicted place and is consequently farther from the earth and so is fainter than was expected. It can be observed in the northeast in the morning with a large telescope.

Comet *e* 1919 (1911 VII Schaumasse).—This comet can be observed in the morning hours in the constellation Virgo. It will move southeastward through Libra during December. It is faint and probably cannot be seen with small telescopes. Approximate positions for November 29 and December 3 are as follows:

Gr. Midnight	R.A.	Dec.
Nov. 29	$14^h\ 01^m.7$	$-0°\ 10'$
Dec. 3	14 15 .5	−1 13

Observations of Comet *d* 1919 (Finlay-Sasaki).—The following are all the observations of the new comet which have come to hand:

G.M.T.	R.A. h m s	Dec. ° ′ ″	Observer	Place
Oct. 24.96	20 17 18	−27 11	Sasaki	Kyoto
Nov. 9.2928	22 27 00.6	−13 23 20	Fayet	Nice
13.5383	23 04 09.2	− 8 11 32	Bower	Washington
13.5451	23 04 12.6	− 8 11 04	VanBiesbroeck	Williams Bay
14.6009	23 13 08.25	− 6 52 51.5	Wilson	Northfield
15.5410	23 20 58.4	− 5 43 32	Barnard	Williams Bay
15.6060	23 21 36.66	− 5 38 53.5	Wilson	Northfield
17.5556	23 37 15.58	− 3 17 51.7	Wilson	Northfield
17.5688	23 37 24.72	− 3 16 44.3	Leavenworth	Minneapolis
18.6643	23 45 54.34	− 2 06 36.8	Wilson	Northfield
19.6134	23 55 11.65	− 0 54 38.4	Wilson	Northfield
21.5838	0 07 38.68	+ 1 15 27.2	Wilson	Northfield

EPHEMERIS OF COMET *d* 1919 (FINLAY-SASAKI)

computed by H. C. Wilson and C. H. Gingrich from the elements in the Harvard College Observatory Bulletin 702.

Date 1919	R.A. h m s	Dec. ° ′	log r	log Δ	Br.
Dec. 1.5	1 09 03	+10 00.8	0.0830	9.4893	0.38
5.5	1 29 04	+12 35.2	0.0938	9.5330	0.30
9.5	1 46 53	+14 42.8	0.1046	9.5765	0.23
13.5	2 02 43	+16 27.7	0.1156	9.6195	0.18
17.5	2 16 58	+17 54.6	0.1266	9.6615	0.14
21.5	2 29 56	+19 07.0	0.1376	9.7022	0.11
25.5	2 41 56	+20 08.5	0.1486	9.7417	0.09
29.5	2 53 01	+21 00.6	0.1594	9.7795	0.07
Jan. 2.5	3 03 24	+21 45.3	0.1701	9.8160	0.06

Comet *d* 1919 (Finlay-Sasaki).—A cablegram has been received here from Professor Luis G. y Carbonell, Director of the Observatorio Nacional, Habana, Cuba, stating that computations by Millas show that observations of Sasaki's Comet by Bonerano and Barnard approximately satisfy Fayet's orbit of Finlay's Comet by changing perihelion to October 15.5.

A later telegram from Professor A. O. Leuschner, Director of the Students' Observatory, Berkeley, California, refers to the comet as the "Finlay-Sasaki Comet," and gives the following elliptical orbit, and ephemeris, computed by Professor Crawford, Miss Fairfield, and Miss Cummings, from observations on November 9, 12, and 15. The period is assumed.

ELEMENTS.

Time of perihelion passage	(T)	1919, October 15.52 G.M.T.
Perihelion minus node	(ω)	318° 15′
Longitude of node	(Ω)	46° 55′
Inclination	(i)	3° 23′
Perihelion distance	(q)	1.013
Eccentricity	(e)	0.7146
Periodic time	(P)	6.69 years

EPHEMERIS.

G.M.T		R.A. h m s	Dec. ° ′	Light
1919, November	19.5	23 52 20	— 1 2	0.74
	23.5	0 21 2	+ 3 15	
	27.5	0 46 38	+ 6 57	
December	1.5	1 9 18	+10 3	0.38

A second telegram from Professor Leuschner states that observations by Jeffers, at the Lick Observatory, on November 3 and 4, confirm the 72-year period of the Brorsen-Metcalf Comet.

S. I. BAILEY.

Harvard College Observatory Bulletin 702,
Cambridge, Mass., U.S.A., November 19, 1919.

New Elements of Comet *a* 1919 (Kopff's Periodic).— In the *Astronomische Nachrichten* No. 5016 Mr. A. Klose of the Breslau Observatory gives new elements of Kopff's periodic comet depending on observations made at Königstuhl July 31 and August 20 and at Vienna September 16.

EPOCH 1919 SEPT. 16.5 G.M.T.

$M = 12° 01' 08''.7$
$\omega = 19 43 51.0$
$\Omega = 263 48 51.4$ } 1919.0
$i = 8 41 30.1$
$\phi = 30 56 40.6$

$\mu = 538''.904$
$\log a = 0.545664$
$T = 1919$ June 28.210 G.M.T.
Period = 6.5841 years

The comet is exceedingly faint now and beyond the reach of small telescopes.

Comet *b* 1919.—This comet is now getting far from the earth and too far south for northern observers. It may still be followed by southern observers in the morning hours. The following ephemeris was calculated by Julie Marie Vinter-Hansen from new elements by J. Braae and J. Fischer-Petersen of the Copenhagen Observatory. The period which they obtain is 69.628 years, but the eight observations used, extending from August 21 to November 1, are not very well represented.

EPHEMERIS OF COMET *b* 1919 FOR GREENWICH MIDNIGHT.

Date		R.A. h m s	Dec. ° ′	log r	log Δ	Mag.
Dec.	2	13 42 42	— 20 44.7	0.0500	0.2297	9.8
	6	13 51 27	22 14.3	0.0753	0.2406	10.0
	10	13 58 48	23 38.1	0.0990	0.2502	10.2
	14	14 5 46	24 56.7	0.1212	0.2588	10.3
	18	14 12 19	26 10.8	0.1421	0.2664	10.5
	22	14 18 31	27 20.8	0.1618	0.2731	10.6
	26	14 24 18	28 27.3	0.1804	0.2788	10.7
	30	14 29 40	— 29 30.4	0.1981	0.2838	10.8

Comet *c* 1919 also is in unfavorable position for northern observers, but may be followed during this month by observers in the southern hemisphere. No ephemeris is at hand for December.

COMMUNICATIONS.

Does An Unknown Force Perpetuate Diurnal Rotation?—The spheres which, with the sun, constitute the solar system, may be divided into two classes: those having diurnal rotation, like our earth; and those which lack such rotation, like Venus, Mercury, our moon, and presumably all the other satellites. Now, a remarkable circumstance is, that diurnal rotation is always coincident with the presence of one or more satellites which revolve around the rotating body; whereas all bodies that lack satellites also lack rotation. This condition is the very opposite to that which we should be led to expect, especially in a comparison of the dead state of Venus and Mercury with that of living planets, whereon notwithstanding the greater proximity of the former to the sun, the brake of the tides should have been far more potent, due to the attraction of their moons plus that of the sun.

Do not these facts suggest the propriety of an inquiry whether, sustained diurnal rotation being always coincident and concurrent with the presence of satellites, it may not be also contingent upon their presence; whether there may not exist some unknown (X) force, or some unfamiliar law directing known forces, which operates, in the case of planets having satellites, to counteract by positive acceleration the negative acceleration due to tidal friction; whether perhaps the earth, for example, as regards rotation, has not attained a state of stable equilibrium, insuring days of uniform length through incalculable periods of astronomical time. In such a case the force opposing the retarding effects of tidal friction would be, not unaided primordial momentum, but primordial momentum plus X.

If we assume the existence of such an X force, it is only necessary to define it as a force of minor magnitude, just a sufficient auxiliary to primordial momentum to postpone or perhaps forever prevent the death of the planets.

Proof of X would necessarily include proof of the proposition that when, under certain conditions, one body revolves around another, rotation of the latter is accelerated.

The moon and other satellites may be powerful magnets which point their same poles always toward their primaries; and that this, if the distance be not too great, would accelerate the primaries' rotation seems certain. An iron sphere so suspended as to be free to move will be made to rotate if the pole of a magnet is revolved around it at proper distance. This may be proved by a simple experiment.

Or perhaps the following proposition may some day be accepted: "When (while) their common center of gravity resides within one of two bodies having relative angular motion, the rotation of that body is accelerated." In the light of our present knowledge, such an hypothesis as this would appear visionary indeed; and yet, as the center of gravity of the system which each planet forms with its moon, or with each of its moons where there are more than one, is invariably situated within the body of the planet itself, this circumstance might well have some direct bearing on the question of the existence of the postulated X force.

JOHN W. BARR.

Cincinnati, Ohio.

GENERAL NOTES.

To Our Subscribers.—The publishers of POPULAR ASTRONOMY have been reluctant to increase the price of the magazine, hoping that the cost of printing might go down soon enough for us to stand the temporary loss. Instead of decreasing, however, in the last few months the cost has greatly increased, so that we are forced to add to our annual subscription price. This small increase of 50 cents may not be sufficient and we hope that our subscribers will not be unduly disturbed if they find the number of pages less than usual in some of the numbers. We will try to keep the quality of the magazine up to its present standard.

Mr. C. J. Merfield has been appointed Chief Assistant Astronomer of the Melbourne Observatory.

Johann Adolf Repsold of the well-known firm of instrument makers in Hamburg, Germany, died on September 1 at the age of 82. Three generations of Repsolds have carried on the business of making astronomical instruments for 120 years, the original founder of the workshops being the friend of Gauss, Bessel, Olbers, Schumacher, etc. J. A. Repsold was best known to astronomers for the meridian circles which were made under his direction, and for his invention of the "moving-wire micrometer" to free transits from personal equation. He wrote a good deal on the history of measuring apparatus.

Twenty-four Hour Time.—In *The Observatory* for October 1919 it is stated that a Committee has been appointed by the Home Secretary to consider and report as to the advisability of adopting in the United Kingdom, for official and other public purposes, the twenty-four hour method of expressing time.

Daylight Saving.—In the October 18, 1919, number of the *Scientific American* are given a number of letters written to the Editor concerning the Daylight Saving plan. Curiously, nine out of ten letters condemn the plan, while only one very brief one favors it.

A New Star has been found by Miss Mackie during the systematic search for such objects now in progress at this Observatory. In some ways it is different from any star hitherto known. It has not been found on any plate taken earlier than August 20, 1919. Its magnitude on that date was 9.4. On September 13 it was about 7.5. Striking fluctuations have occurred since that time. Its magnitude is now 9.5. Miss Cannon finds the spectrum very peculiar, with numerous bright lines, somewhat resembling that of Eta Carinae. The position is, R.A. $18^h\ 9^m\ 27^s$, Dec. $+11°\ 35'.1$ (1900). A twelfth magnitude star precedes the nova 15^s, north $1'.7$, and a fourteenth magnitude star precedes 2^s, south $1'.3$.

A circular will be issued later giving greater details, but meanwhile photographs of its spectrum with large instruments would have much interest.

S. I. BAILEY.

Harvard College Observatory Bulletin 696.
Cambridge, Mass., U. S. A., October 22, 1919.

The Brussels Observatory Little Injured.—We are gratified to learn "From an Oxford Note-Book" in *The Observatory* for October 1919 that the Germans had respect enough for the scientific work of the Brussels Observatory to give orders that the scientific instruments should be spared. "Most of the metal door-knobs have disappeared from the Observatory as from elşewhere in Brussels, but one remains; it is that of the door to the glass case which enshrines the transit-circle, and it was saved by the thoughtful remark of the observer that it was part of a scientific instrument."

Wave-Lengths in the Spectra of Krypton and Xenon.—In the *Scientific Papers* of the Bureau of Standards, No. 345, Mr. Paul W. Merrill gives the results of his measurements of the wave-lengths in the red and infra-red spectral regions of the elements of krypton and xenon. For krypton 37 new lines were measured between 6576 A and 8928 A; for xenon 52 new lines between 6318 A and 9162 A. In this region there are numerous strong lines which are probably among the most important in the spectra of these elements.

The Partial Solar Eclipse November 22, 1919.—At Northfield the sun rose with the eclipse already on. At 7:45 C.S.T. the moon covered a little more than half the diameter of the sun. Last contact was observed by H. C. Wilson with the 16-inch telescope. The definition was poor but the time of observed contact was probably within 1 second of correct. Two records were made as follows:

Black notch uncertain at	9^h	00^m	$15^s.4$	C.S.T.
" " certainly gone at	9	00	18.8	"
Adopted time of last contact	9	00	17.1	"

The Magnetic Polarity of Sunspots.—In the April 1919 number of the *Astrophysical Journal* is a very interesting, though technical, article on the Magnetic Polarity of Sunspots by George E. Hale, Ferdinand Ellerman, S. B. Nicholson, and A. H. Joy, of the Mount Wilson Observatory. The article is illustrated with several photographic plates showing the methods used in the study of sunspots at Mount Wilson.

The first definite evidence of whirling motion in sunspots was obtained with the spectroheliograph in 1908. Photographs of the hydrogen flocculi made with the $H\alpha$ line showed clearly marked vortical structure in regions centering in sunspots. "These photographs suggested the hypothesis that a sunspot is a vortex, in which electrified particles, produced by ionization in the solar atmosphere, are whirled at high velocity. This might give rise to magnetic fields in sunspots, regarded as electric vortices. A search for the Zeeman effect led to its immediate detection, and abundant proofs were soon found of the existence of a magnetic field in every sunspot observed."

Two classes of vortices have been found, (1) high-level hydrogen vortices, centered in sunspots, but extending to great distances around them, and (2) low-level vortices formed in the photosphere and constituting the sunspots themselves. In the first class the motion of the hydrogen gas appears to be spirally inward and downward, in the second it appears to be spirally upward from the photosphere and outward along its surface.

Sunspots may now be classified in three groups with reference to polarity:

(α) Unipolar spots.—Single spots or groups of small spots having the same magnetic polarity.

(β) Bipolar spots.—Two spots or groups of spots near each other but of opposite polarity.

(γ) Multipolar spots.—Groups which contain spots of both polarities irregularly distributed.

About 60 per cent of all sunspots are binary groups, the single or multiple members of which are of opposite magnetic polarity.

The Solar Eclipse of May 29, 1919.—The following extract from *The Observatory* for October 1919 gives the substance of a report by Prof. A. S. Eddington on the observations of the total eclipse of the sun last May on the Island of Principe and in Brazil:

"Two expeditions were sent out by the Permanent Eclipse Committee of the Royal Society and Royal Astronomical Society. The problem was to test the effect of gravitation on the path of a ray of light. We might compare light to a rifle-bullet which is deflected from a straight line by gravitation—the displacement being 16 ft. in one second, 64 ft, in two seconds, etc. The Earth is so small that light passes through its effective field of gravitational attraction in a fraction of a second. It is, therefore, impossible to test the theory by the effect of the Earth. But light takes several seconds to pass through a distance equal to the Sun's diameter, and the Sun's gravitational field is stronger than the Earth's. If light passes close to the Sun it might be appreciably deflected. The eclipse in May of this year was a specially favorable one, as there are many bright stars situated in the part of the sky where the Sun was eclipsed. It may be a century or more before an eclipse will again occur under circumstances so favorable for testing the theory.

"The problem is, however, one of great practical difficulty. The quantities involved are of sufficient magnitude to be detected under the ordinary conditions of astronomical observations, but the effect which is sought after has to be disentangled from differences due to scale, aberration, refraction, etc. The fact that the field has to be photographed under the different conditions of day and night increases the practical difficulties enormously.

"For the eclipse Prof. Eddington and Mr. Cottingham took with them to Principe the object-glass of the Oxford Astrographic Telescope. With this telescope plates of the field had been taken at Oxford before the expedition left. The day of the eclipse was disappointing. The sky was covered with cloud, not very thick, and the Sun at times shone through rifts. Sixteen plates were exposed in the five minutes available. Of these, the first ten plates were failures, as they showed no stars, the other plates showed a maximum of five stars, instead of the 12 or 13 which had been hoped for. On the other hand, the expedition to Brazil for the same purpose, undertaken by the Greenwich observers, may be described as completely successful, though they had some clouds also. The plates obtained should settle the question.

"A remarkable prominence was shown on the plates. The prominence had a height of over a hundred thousand miles. These direct photographs of the prominence show much greater detail than those taken with the spectro-heliograph. A beautiful stereoscopic effect is obtained from photographs taken at two-minute intervals. The cloud was really helpful in some of the plates for show-

ing up the prominence, for the plates taken towards the end of the eclipse are very much overexposed, so far as the prominences are concerned. The improvement of the conditions during the eclipse are well illustrated by the corona, well shown in 3-second exposures, compared with the earlier exposure of 20 seconds, which does not show the corona. The eclipse took place in Brazil about two and a half hours before it took place in Principe, and the one plate spoilt by cloud in Brazil shows the prominence very well. We thus have good photographs of the prominence separated by a considerable interval of time.

"The calculated displacement of a star at the Sun's limb due to the gravitational effect is 0".87, with Einstein's theory of relativity it is 1".75. The problem is to find whether or not there is a deflection, and if there is a deflection the amount of it. If the larger effect is obtained, the displacement of stars in the field will be of the order of 1". This is a quantity easily measured, but the conditions make it difficult to get good plates.

"It is impossible to give the results yet. The Greenwich plates should be measured and reduced in a few weeks."*

A Correction in Orientation.—The solar photographs published in the October number of POPULAR ASTRONOMY as approximately oriented regarding the eastern and western points are correct, but the northern and the southern points should be interchanged. The matter is interesting in that the photographs being taken with a single reflection require this interchange of north and south and to be viewed correctly the image should be seen in a mirror.

I am indebted to Mr. Dean B. McLaughlin of Ann Arbor, Mich., for calling attention to this error in the orientation.

1405 Gartland Ave., Nashville, Tenn. LATIMER J. WILSON.

The Periodic Comets.—This return of the Brorsen comet adds a fifth member to the list of comets of fairly long period noted at two or more visits. The others are the Pons-Brooks comet of 1812 and 1884, Olber's comet of 1815 and 1887, Westphal's comet of 1852 and 1913, and last but not least Halley's comet, by far the most conspicuous as well as the most famed of all periodic comets, which has been observed at every one of 26 successive returns from B. C. 87 to A. D. 1910. Two more comets are known, of above the same period—De Vico's comet of 1847, figured at that time to have a period of some 75 years; and the second visitor of 1827, which, according to recent computations by the Japanese astronomer Ogura, has a period of about 64 years and must have returned unobserved some time around 1897. As the relatively few and inaccurate observations of this are satisfied with substantial accuracy by orbits of periods anywhere from 59 to 69 years, the accumulated margin leaves us in doubt whether the next return will be as early as 1945 or as late as 1965. The similar uncertainty in the case of De Vico's comet amounts to two or three years on either side of 1921 so that it is probable, when either one of these is seen again, it will masquerade as a new comet until calculation has an opportunity to show it is moving along the path of an old one. This is what happened in the case of the Pons-Brooks comet, and again this year for the one still in sight. (Professor Henry Norris Russell, in *Scientific American*, November 1, 1919.)

---

*As this form of POPULAR ASTRONOMY goes to press, we have received from the Royal Society a printed announcement that the measures of the photographs referred to actually show deflections of several stars agreeing closely with the requirements of the Einstein theory.

Supplement to Popular Astronomy, No. 270.—The following ephemerides of comets *b*, *c*, and *d* 1919 are taken from the Lick Observatory Bulletin No. 325, which arrived after the regular forms of the December number of Popular Astronomy had gone to press. They were all computed for Greenwich midnight.

Ephemeris of Comet *b* 1919 (Brorsen-Metcalf)

By H. M. Jeffers.

1919	R.A. h m s	Dec. ° ′	log Δ	Br
Dec. 1.5	13 41 38	−20 21.8		
3.5	45 36	21 07.9		
5.5	49 28	21 52.7	0.2381	0.15
7.5	53 14	22 36.0		
9.5	13 56 56	23 17.8		
11.5	14 00 30	23 58.6		
13.5	03 58	24 37.7	0.2569	0.11
15.5	07 20	25 16.1		
17.5	10 37	25 53.0		
19.5	13 48	26 28.9		
21.5	16 54	27 03.9	0.2716	0.09
23.5	19 53	27 37.9		
25.5	22 46	28 11.2		
27.5	25 33	28 43.6		
29.5	28 14	29 15.2	0.2828	0.07
Dec. 31.5	14 30 49	−29 46.1		

Ephemeris of Comet *c* 1919 (Metcalf-Borrelly)

By W. F. Meyer.

	R.A. h m s	Dec. ° ′ ″	log Δ	Br
Dec. 3.5	18 35 06	−23 44 11	0.2782	2.95
5.5	43 15	24 36 58		
7.5	51 31	25 28 01		
9.5	18 59 32	26 17 11		
11.5	19 08 22	27 04 24	0.2800	2.92
13.5	16 58	27 49 32		
15.5	25 41	28 32 30		
17.5	34 31	29 13 12		
19.5	43 26	29 51 33	0.2837	2.80
21.5	19 52 27	30 27 29		
23.5	20 01 33	31 00 55		
25.5	10 43	31 31 49		
27.5	19 57	32 00 06	0.2890	2.59
29.5	29 14	32 25 46		
Dec. 31.5	20 38 34	−32 48 46		

Ephemeris of Comet *d* 1919 (Finlay-Sasaki)

By R. T. Crawford, Priscilla Fairfield and Edith E. Cummings.

	R.A.			Dec.			log Δ	Br
	h	m	s	°	′	″		
Dec. 1.5	1	09	18.0	+10	03	10	9.4891	0.38
2.5		14	32.1		10	44	31	
3.5		19	36.6		11	23	57	
4.5		24	31.8		12	01	32	
5.5		29	18.1		12	37	20	9.5326	0.30
6.5		33	55.9		13	11	26	
7.5		38	25.6		13	43	54	
8.5		42	47.4		14	14	50	
9.5		47	01.7		14	44	17	9.5763	0.23
10.5		51	08.7		15	12	20	
11.5		55	08.8		15	39	04	
12.5	1	59	02.4		16	04	33	
13.5	2	02	49.7			28	51	9.6194	0.18
14.5		06	31.1		16	52	02	
15.5		10	06.9		17	14	10	
16.5		13	37.3			35	18	
17.5		17	02.7		17	55	30	9.6614	0.14
18.5		20	23.3		18	14	48	
19.5		23	39.3			33	16	
20.5		26	51.0		18	50	56	
21.5		29	58.6		19	07	52	9.7021	0.11
22.5		33	02.3			24	05	
23.5		36	02.2			39	38	
24.5		38	58.7		19	54	33	
25.5		41	51.8		20	08	52	9.7415	0.09
26.5		44	41.7			22	37	
27.5		47	28.7			35	50	
28.5		50	12.9		20	48	33	
Dec. 29.5	2	52	54.5	+21	00	47	9.7794	0.07